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VOL. XLIII

JUNE, 1934

No. 2

Annals of Otology, Rhinology and Laryngology

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PUBLISHED QUARTERLY
BY THE ANNALS PUBLISHING CO.
7200 WYDOWN BLVD.
ST. LOUIS, MO., U. S. A.

SUBSCRIPTION PRICE, \$6.00 PER ANNUM, IN ADVANCE

Subscription price in Canada, \$6.40.

Subscriptions in other countries of the Postal Union, \$6.80.

Entered at the Postoffice, St. Louis, Mo., as Second-class Matter.

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ANNALS
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XXV.

THE ELECTRICAL ACTIVITY OF THE COCHLEA IN
CERTAIN PATHOLOGIC CONDITIONS.*

M. H. LURIE, M. D., H. DAVIS, M. D., AND

A. J. DERBYSHIRE, A. B.,

BOSTON.

In our experimental work on the physiology of the ear, no animals with abnormal hearing or recognized pathologic conditions of the middle ear were encountered until early in 1933. Since then we have accumulated a small group of cases, both cats and guinea pigs, with various abnormalities of some otologic interest.

The electrical activity of the cochlea and the action potentials in the auditory nerve of all these animals were recorded by means of amplifiers and the cathode ray oscillograph which we have employed in our experimental analysis of the auditory mechanism and has recently been described elsewhere in some detail.¹ All animals which, in any of our experiments, gave indications of functional abnormalities of any kind were subjected to post-mortem examination. The middle ears and the petrous bones were removed, fixed in Helley's solution, sectioned and studied

*Read at American Otological Society meeting, April 6, 1934.

Departments of Otology and Laryngology, and of Physiology, Harvard Medical School.

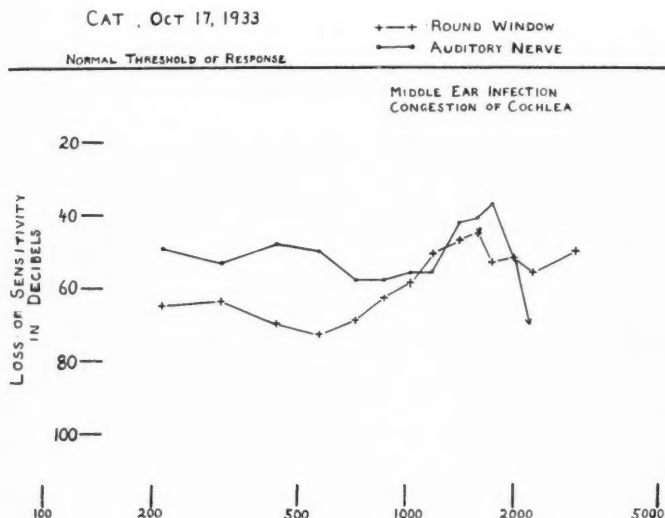


Fig. 1. Audiogram of cat experimented on October 17, 1933, showing a loss of sensation units averaging about 50 through the range studied.

for evidence of pathologic changes. A number of animals giving normal responses were similarly examined as controls.

The cases fall into two main groups: First, those with infection of the middle ear, and secondly, those with normal middle ears.

The presence of evidence from old infectious processes, such as thickening of the bony wall of the bulla, and of plugs of wax in the external canal, is not necessarily associated with any demonstrable deficiency or abnormality of response. The simplest abnormality associated with infection is a raised threshold of response.

October 17, 1933. The middle ear and bulla of this cat were filled with granulation tissue and pus. The tympanic membrane, malleus and incus were absent, and the bone of the labyrinthine capsule was eroded, especially over the basal whorl of the cochlea. The round window was filled with granulation tissue. The periosteum was markedly thickened and the external meatus was closed with wax and pus.

At operation, the external canal and bulla were cleaned as completely as possible. The electric response from the round window and from the eighth nerve were both obtained, but with elevated thresholds. The audiogram for each type of response appears in Fig. 1. The nerve threshold is



Fig. 2. Cat—October 17, 1933. Organ of Corti normal. Spiral ganglion and auditory nerve appear normal, but there is a marked passive congestion throughout.

raised 50 db. Sensitivity by round window response is even less, probably due to electrical shunting by granulation tissue on round window. The upper and lower limits are essentially normal if allowance is made for the elevated thresholds.

On sectioning the cochlea it was found that the principal lesion was a low-grade infection with marked passive congestion of the blood vessels. The congestion included the lamina spiralis ossea. The organ of Corti and spiral ganglion both appeared normal. (Fig. 2.)

The functional deficiency in this case is readily explained on the basis of mechanical damage to the transmission mechanism and probably also by passive congestion of the mechanisms of the inner ear.

January 13, 1933. This animal showed a very similar condition, the bullae and middle ears being filled with granulations and pus. Malleus, incus and tympanic membrane were missing. The outer bony wall of the first turn of the cochlea showed marked erosion and the round window was filled with granulations.

Test showed that the response of the cochlea was essentially normal except for an elevated threshold. The "hearing loss" amounted to about 40 sensational units at all points tested. Attempts to detect action currents from the auditory nerve and from the nuclei of the auditory pathways were completely unsuccessful. Two hours were spent in efforts to find a region in the midbrain which would yield responses to auditory stimulation. Postmortem examination showed that electrodes had been successfully placed in the eighth nerve and in the inferior colliculus at points usually yielding strong responses. The pathologic condition of the ears was bilateral, so that we lack the control provided in animals with unilateral lesions, but the sensitivity of the apparatus was demonstrated by detecting other types of physiologic activity in the brain stem.

Histologic examination of the ears showed a marked middle ear infection with infiltration of the bony capsule. The organ of Corti is normal in appearance (Fig. 3). The spiral ganglion shows a definite diminution in the number of ganglion cells, a degeneration of ganglion cells, and a growth of new fibrous tissue. There is also marked proliferation of the blood vessels with passive congestion. The cochlear nerve shows evidence of degeneration and a chronic infection of the sheath, especially where it is in contact with the modiolus.

This case is unique in our experience in showing a fairly normal cochlear response with complete absence of neural activity. It shows that the two may be dissociated by a pathologic process of the type described, and from the theoretical point of view demonstrates the independence of the cochlear response from the activity of the nervous tissues.

Another animal showing marked infection of the cochlea was a waltzing guinea pig. This animal behaved as though completely deaf, and in the acute experiment yielded no electrical responses, either from round window

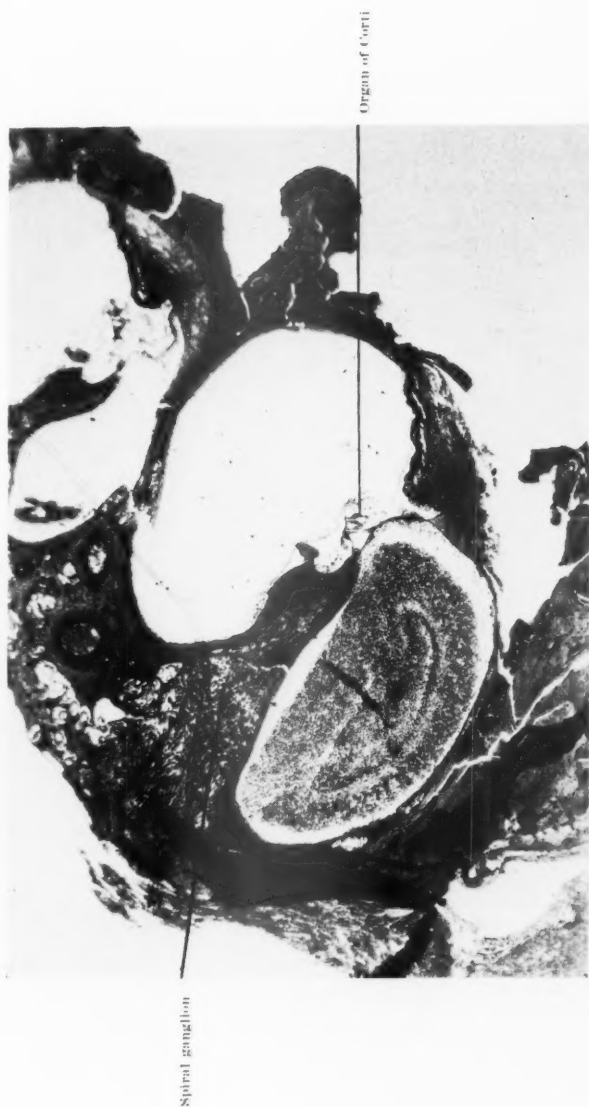


Fig. 3. Cat experimented on January 13, 1933. Organ of Corti normal. Stiral ganglion shows degeneration. The cochlear nerve shows evidence of degeneration and disorganization of the sheath. There is a blood clot in the scala tympani due to infusion of blood through the aqueductus cochlearis.

or from auditory nerve. The subsequent examination showed a definite infection of the cochlea in both ears; but since other animals of this type show marked congenital deficiencies of the organ of hearing, no significant conclusions can be drawn.

The second group of animals are those with congenital abnormalities of the auditory mechanism. In some cases this has resulted in a complete functional deficiency. One of these cases, a white cat with right eye blue and left eye yellow, has been reported previously,¹ but is of particular interest.

Preliminary observation assured us that the animal heard well, being extremely responsive to slight sounds. At operation both middle ears, drums and bullae were completely normal in appearance. The cochlear response recorded from the left round window was normal in respect to threshold, magnitude and wave form. Action potentials were detected in the homolateral inferior colliculus in response to stimulation of this ear, and subsequent histologic examination showed a completely normal cochlea (Fig. 4). From the round window on the side of the blue eye, however, no electrical disturbance whatever could be detected at a sensitivity of 1 meter per millivolt. Neither could action currents be detected in the contralateral inferior colliculus, which is usually extremely sensitive and which had been proved responsive to homolateral stimulation. Fig. 5 shows the condition of this cochlea. The organ of Corti is absent from end to end. Reissner's membrane and the basilar membrane are fused so as to obliterate the scala media. The spiral ganglion has degenerated so that but few of the ganglia cells are present, and the cochlear nerve shows a corresponding diminution in number of fibers.

The absence of electric response correlated with an absence of gross abnormality of the organ of Corti in albinotic cats confirms observations previously reported by Crowe and Hughson.² Another animal probably belongs in the same group, to judge by the nature of the anatomic deficiency subsequently found, although it showed none of the external albinotic characteristics except for pink eye-grounds devoid of the usual feline pigmentation.

December 15, 1933. This animal yielded a response from the round window of the right ear when very strong stimulation was employed, and, in addition to the generally elevated threshold, there seemed to be complete absence of response to frequencies above 4096. Fig. 6 shows the audiogram of this cochlear response. Electrodes placed in the eighth nerve detected faint electric activity, but the nature of this is in doubt. It showed no latency with respect to the response recorded from the round window, but in wave form resembled action potentials more than cochlear response. No evidence of action potentials could be obtained from the cochlear nucleus. The round window response may have been primarily action potentials. Satisfactory analysis of this case was impossible as the entire response failed rapidly soon after electrodes were introduced into the eighth nerve.



Fig. 4. Normal side of Albino cat showing normal organ of Corti and spiral ganglion.

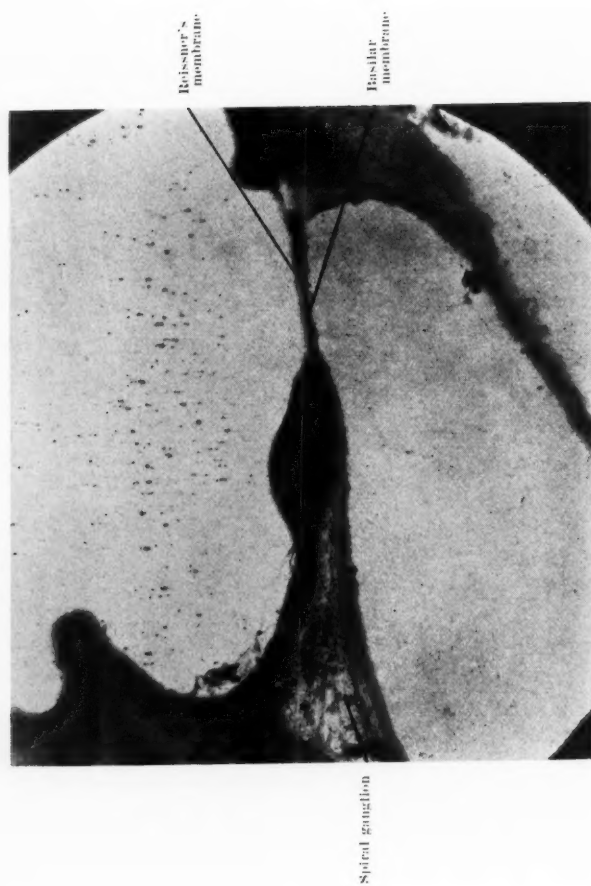


Fig. 5. Deaf side of Albino cat. No organ of Corti present. Reissner's membrane and basilar membrane are fused. Strial ganglion has a few ganglion cells present. Cochlear nerve showed marked diminution in the number of nerve fibers.

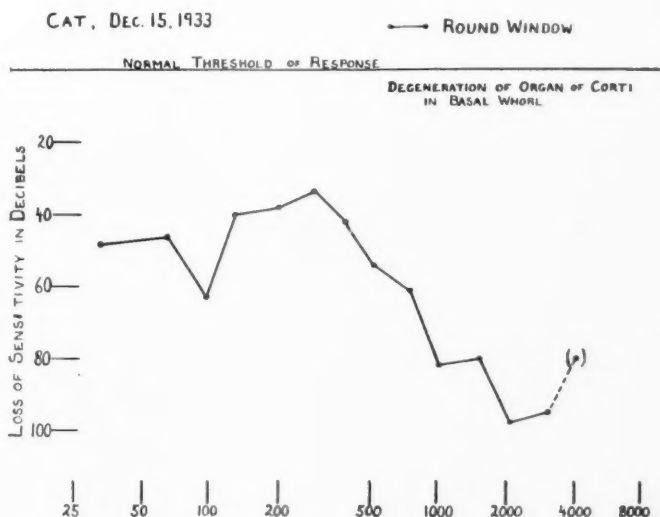


Fig. 6. Audiogram of cat experimented on December 15, 1933. Round window response showing gradual loss of response from 300 d.v. to 4000.

The basal whorl of this cochlea shows a complete degeneration of the organ of Corti (Fig. 7). The spiral ganglion is markedly deficient in the number of ganglia cells. In the apical turn and a half of the cochlea the organ of Corti is present and also a spiral ganglion which seems practically normal.

The complete absence of response to very high tones is here correlated with degeneration in the basal turn. This is in accord with the findings of Guild³ and his collaborators in human material. It is perhaps a little surprising to have detected any response whatever to a tone as high as 4000 when an organ of Corti can be demonstrated only in the upper turn and a half. The presence of action potentials without cochlear response would be a point of considerable interest. However, the curve shows a definite fall beginning at about 350 d. v. We hesitate on the basis of this incomplete and rather unsatisfactory case to accept the alternative explanation that nerve impulses may arise without an electric response of the organ of Corti, for we believe that this electrical phenomena probably is the mechanism for stimulation

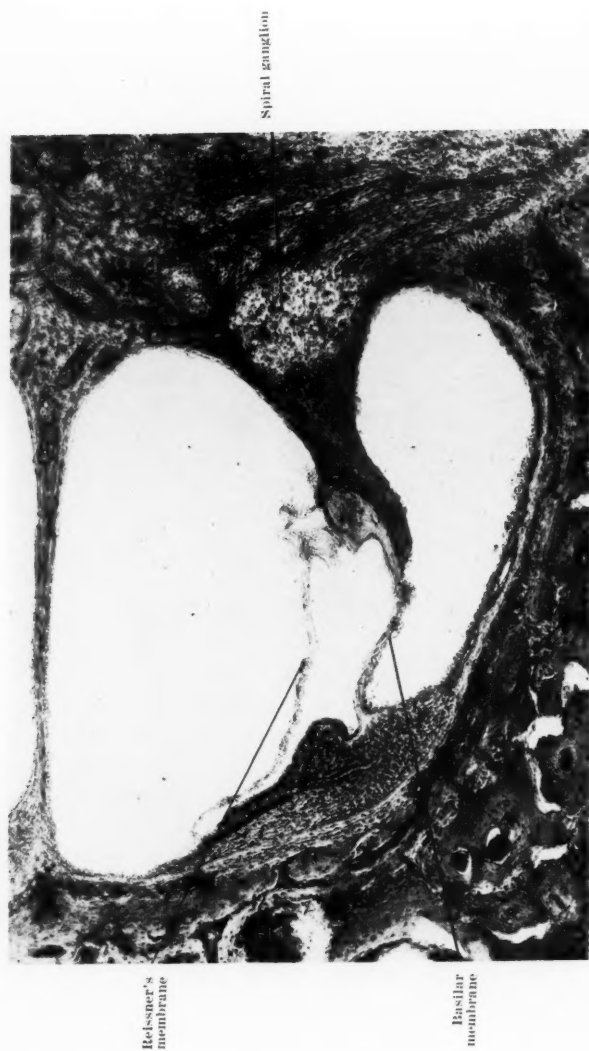


Fig. 7. Cat—December 15, 1933. Basilar turn of cochlea. Absence of organ of Corti. Spiral ganglion shows marked degeneration. Reissner's membrane and basilar membrane in their normal relationship.

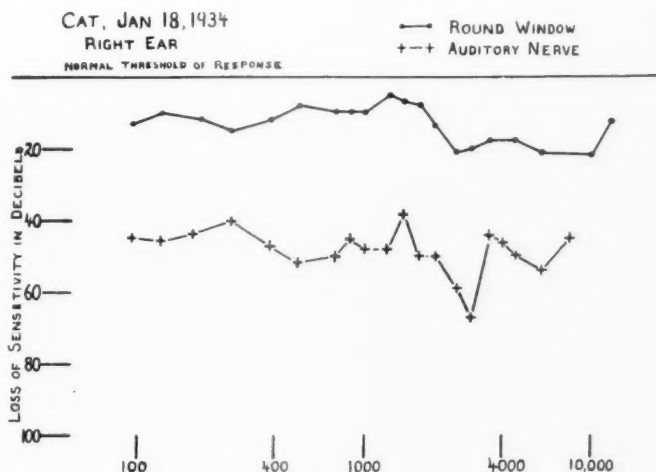


Fig. 8. Audiogram of right ear of cat experimented on January 18, 1934. Response from round window and auditory nerve. Round window response being from 10 to 20 sensation unit loss below the normal threshold. Auditory nerve response shows loss averaging about 50 sensation units.

of the nerve fibers. The case does, however, show the impossibility of drawing conclusions as to the degree of normality of the auditory mechanism as a whole from a study of the round window response alone.

Another complicated condition was found in a white cat with blue eyes and pink eye-grounds and who acted as though he were partially deaf.

January 18, 1934. The middle and external ears on both sides were found completely normal at operation. The cochlear response on the right side was within normal limits, both qualitatively and quantitatively. Its "audiogram" lies ten to twenty db below our control group (Fig. 8). The response of the auditory nerve on this side was definitely deficient. The action potentials were normal as to latency, wave form, etc., but their threshold was elevated some 35 db above that of the cochlear response. The eighth nerve was described at the time of operation as "very thin." The raised threshold probably is related to a numerical deficiency in fibers. The response from the right cochlear nucleus was remarkably poor. It was, in fact, very difficult to demonstrate any response but to stimulation of the left ear. This activity of the cochlear nucleus during contralateral stimulation has not been described previously. Ordinarily it would be difficult to prove, due to the likelihood of spread of the stimulating sound by bone conduction or otherwise to the homolateral ear.



Fig. 9. Right ear of cat experimented on January 1, 1934. Hemorrhage in auditory nerve. Cochlea normal. Macula of the saccule and utricle are shown.

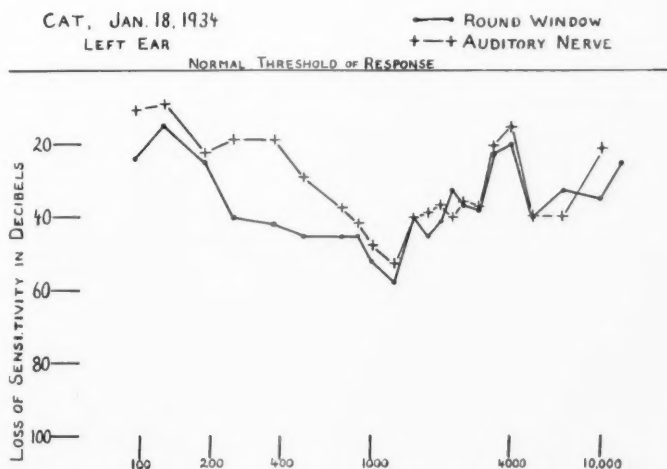


Fig. 10. Audiogram of left ear of cat experimented on January 18, 1934. Response from round window and auditory nerve. Showing loss of sensation unit response from tones 200 to 4000 averaging about 40. Note that the curve from the round window and auditory nerve follow each other fairly closely.

The physiologic picture of the right side is, therefore, one of normality at the organ of Corti and abnormality of the neural mechanism, resulting in a high degree of right-sided deafness by the time the level of the cochlear nucleus has been reached.

Examination of this ear showed normal organ of Corti, normal spiral ganglion, but there was considerable hemorrhage in the cochlear nerve at the region of the modiolus and internal auditory meatus. The nerve itself appeared smaller when compared with the left cochlear nerve (Fig. 9).

The physiologic picture is quite different on the left side. The threshold for cochlear response is high, particularly for the middle range of frequencies. In the frequency range between 200 and 800 the wave form of the cochlear response was unusually irregular. The modifications were interpreted at the time as due to the presence of strong harmonics introduced by nonlinear distortion, but in view of more recent observations it is probable that a relatively strong action potential component was one of the interfering waves. Fig. 10 shows the audiograms of cochlear response and of action potential of the auditory nerve. The latter follows the cochlear response with the usual fidelity except in the range through which the wave form of the cochlear response was abnormal. Here the threshold of nerve response is actually somewhat lower.

Examination of this ear showed normal organ of Corti, normal spiral ganglion, and normal cochlear nerve, but there was periosteal infection of the inner wall of the middle ear with the stapes filled with thickened periosteum. The infection appears to have come from the eustachian tube.



Fig. 11. Left ear of cat experimented on January 18, 1974. Cochlea and cochlear nerve normal. Section shows condition found in the region of the oval window and stapes. Stapes filled with fibrous connective tissue secondary to a previous infection. Relationship of stapedius muscle and facial nerve are also shown.



Fig. 12. Waltzing guinea pig experimented on March 6, 1933. Third whorl of cochlea showing degenerated organ of Corti and degenerated spiral ganglion. Note relationship of Reissner's membrane, tectorial membrane, and basilar membrane are normal.



Fig. 13. Waltzing guinea pig, experimented on March 6, 1953. Basal turn of cochlea. Marked degeneration of organ of Corti. There is no tunnel of Corti present. Degeneration of spiral ganglion. Reissner's membrane and basilar membrane in normal relationship.

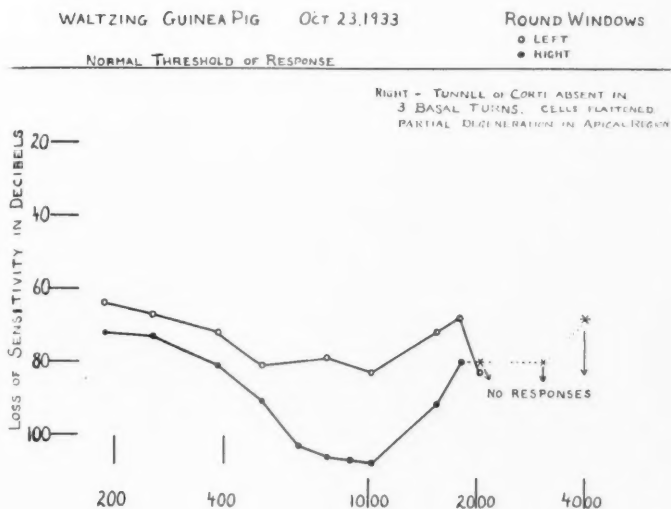


Fig. 14. Audiogram of waltzing guinea pig experimented on October 23, 1933. Response from round windows only. Marked loss of sensation units averaging about 90 on both sides. Tones were not heard above 2000.

The thickening of the periosteum in the region of the stapes is probably the reason for the raised thresholds (Fig. 11).

We obtained two waltzing guinea pigs whose ears were free from infection. These animals in their behavior closely resemble the familiar waltzing mouse. They are unresponsive to sounds. When stimulated to run, or during spontaneous activity, they show circling movements either to the right or left. This is clearly associated with congenital anatomic deficiencies in the labyrinthine mechanism. The following observations show that the deficiency extends to a greater or less extent to the auditory mechanism.

March 6, 1933. This animal showed perfectly normal middle ear and tympanum at operation. Electrically it was completely unresponsive. No evidence of cochlear response could be detected from either ear. The histologic examination shows only moderate pathologic changes. There is definite evidence of degeneration extending upward for at least two turns from the basal end of the basilar membrane. The organ of Corti had degenerated to a layer of flattened cuboidal cells. There was no tunnel of Corti. The spiral ganglia showed marked degeneration. In the two upper whorls the organ of Corti was present but showed degenerative changes.

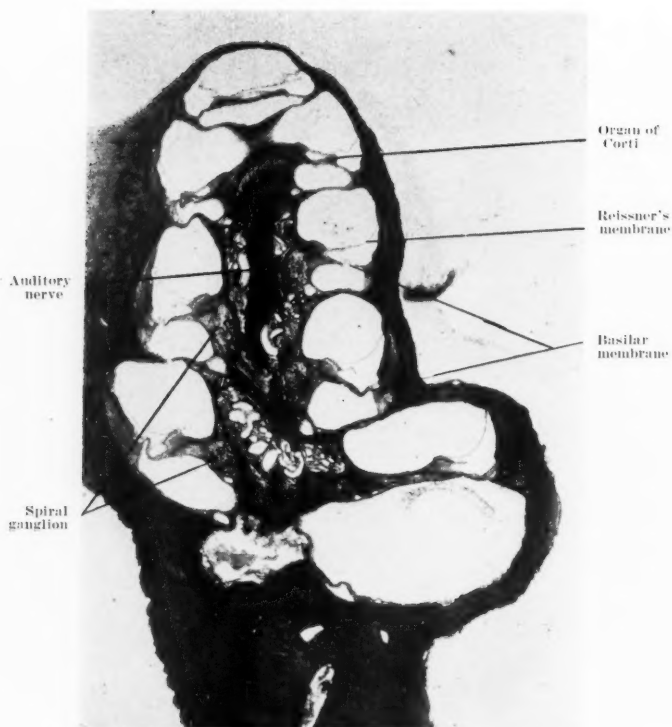


Fig. 15. Right ear of waltzing guinea pig experimented on October 23, 1933. Low power showing cochlea. Degeneration of the organ of Corti for $2\frac{1}{2}$ basal whorls. Organ of Corti present in upper $1\frac{1}{2}$ whorls. Note relationship of Reissner's membrane, basilar membrane, and tectorial membrane are normal throughout.

The hairs of the sensory cells can be distinguished under high power magnification. The spiral ganglia and cochlear nerve also show moderate degenerative changes (Figs. 12-13).

October 23, 1933. This animal was completely similar in behavior to the one just described and equally normal as to middle and external ears. In its response it differed in showing slight electrical activity. From the right round window a small response was obtained with very high threshold to tones below 1800. There is no clear evidence of an abrupt break in the curve. No action potentials could be detected in the auditory nerve, however. The left ear also showed small responses with high thresholds over practically the same frequency range (Fig. 14). The search for action potentials arising from this ear was incomplete, as the animal died during the final exposure of the regions we wished to test. On microscopic examination, the right ear showed definite degeneration in two and a half basal turns. The tunnel of Corti was absent, and the spiral ganglia showed a marked degeneration of the ganglion cells. The upper turn and a half was more nearly normal, although giving evidence of degeneration. The spiral ganglia is practically normal except for a possible reduction in the number of ganglion cells. The cochlear nerve showed a definite diminution in number of fibers (Figs. 15, 16, 17).

The left ear was definitely degenerate in the two basal whorls, while the two upper whorls showed practically normal organ of Corti and spiral ganglion. The left nerve as a whole showed diminution in the number of fibers.

These animals further illustrate the possibility of obtaining small cochlear responses without the initiation of corresponding nerve impulses. Both animals behaved as though completely deaf. In these animals we have additional confirmation of the correlation between abnormality of the organ of Corti in the basal turns and loss of cochlear response to high frequencies of stimulation. This further confirms the interpretation of this response as depending on the functional activity of the organ of Corti. Evidently, however, this activity does not necessarily result in the initiation of nerve impulses. A more surprising feature of this case is the absence of any very sharp break in the threshold curve in spite of a rather sharp transition in the histologic picture. This may depend upon a lack of sharp resonance in the basilar membrane.

The cats and guinea pigs which Dr. Upton exposed to a strong tone of 600 vibrations for periods up to ninety days may be very briefly dismissed and also two guinea pigs similarly exposed by Mr. E. H. Kemp. No abnormalities, either physiologic or histologic, were detected in any of this series. The result is of interest only as indicating a greater degree of resistance of these animals, particularly of guinea pigs, to loud sustained tones than Dr. Upton

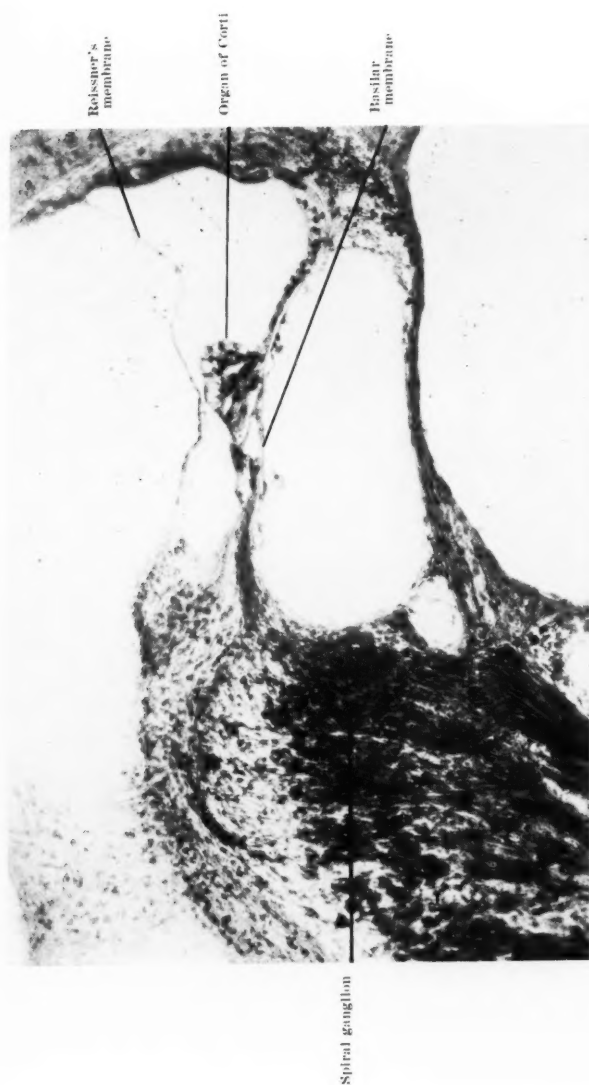


Fig. 16. Waltzing guinea pig experimented on October 23, 1933. Third whorl of cochlea. Showing organ of Corti with degeneration present. Spiral ganglion showing degeneration. Reissner's membrane and basilar membrane are in normal relationship.

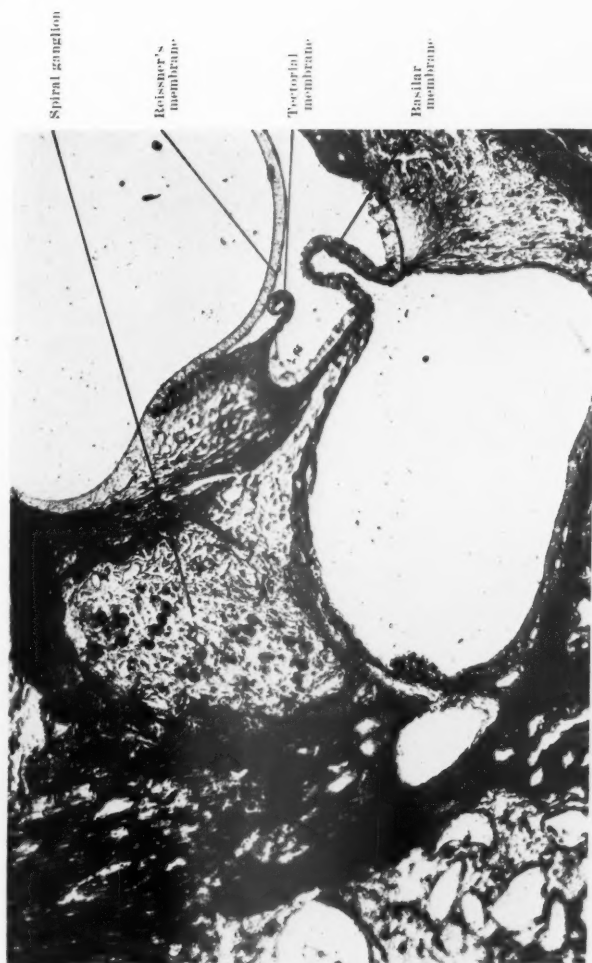


Fig. 17. Waltzing guinea pig experimented on October 23, 1933. Basal whorl. Showing complete absence of organ of Corti and marked degeneration of the spiral ganglion, Reissner's membrane, tectorial membrane, and basilar membrane in normal relationship.

believed possible on the basis of previous experimentation in this field.

We wish to thank Dr. H. P. Mosher for the use of the pathologic laboratory of the Massachusetts Eye and Ear Infirmary, and also Dr. W. Mueller for the photomicrographic work.

CONCLUSIONS.

These observations on pathologic animals, combined with our previous findings on normal animals, confirm our views that

1. The cochlear response depends upon the organ of Corti, for
 - (a) It is absent when the organ of Corti is absent.
 - (b) It has never been absent when the organ of Corti has been entirely normal.
 - (c) Partial degenerations or deficiencies of the organ of Corti give partial, and sometimes complete, deficiencies in the cochlear response.
2. Nerve impulses are probably initiated by the cochlear response, for
 - (a) The threshold curves for both run parallel in most animals.
 - (b) Nerve impulses may be seriously deficient or absent with the cochlear response present.
 - (c) Nerve impulses have not been found in absence of the cochlear response, except
 - (1) When the threshold of the latter is raised by unfavorable local electrical conditions of detection or by interference from nervous response, and
 - (2) In one doubtful incomplete case.
3. The basal portion of the cochlea responds to high tones and the apical portion to low. But with a rather wide extent of physical vibration to strong tones.
 - (a) Deficiency of the organ of Corti in the basal turn causes a greater elevation of threshold in the high than in the low tonal range, but no abrupt transitions have been encountered.
4. The cochlear response is probably a good indicator of the activity of the organ of Corti, but the extent of an animal's hear-

ing can be better evaluated from the action potentials of the auditory nerve. Even this may lead to error in cases of true central nerve deafness.

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XXVI.

SOME OBSERVATIONS ON CLINICAL
OTOSCLEROSIS.*

C. C. BUNCH, PH. D.,

ST. LOUIS.

Scientific interest in otosclerosis antedates its otologic and anatomic description. No problem in otology has been more earnestly and universally studied since the establishment of this branch of clinical medicine. The secrets of its etiology are as elusive today to the methods of modern research as they were to the early investigators, but the interest in the study has not waned. Its elusiveness adds incentive to the search. One has but to glance through the current literature of embryology, histology, pathology, endocrinology and eugenics, in addition to that in otology, to understand the widespread interest in this subject. The studies sponsored by the American Otological Society and other scientific associations as well as the reports by independent investigators show that old concepts are being questioned and that the problem is being approached in a truly scientific manner. Kerrison,¹ with his characteristic freedom and accuracy, sums up the present status of the study with "Unfortunately the enormous amount of work which has in the past been focused upon the pathology of otosclerosis has yielded results of academic interest rather than of practical value to suffering humanity."

Realizing the careful investigations which have preceded, it is with extreme humility that this study is prepared. Its presentation is justified in the writer's mind first, because of an interest in the deafness accompanying otosclerosis; second, in order to add, if possible, some more or less pertinent evidence as to the clinical symptoms accompanying the disease in the patients which have been studied; and third, to raise some queries concerning certain concepts which are, historically at least, quite firmly established.

*From the Oscar Johnson Institute, Department of Otolaryngology, Washington University Medical School.

This study has been made possible through the Ball Fund.

Politzer's definition of this disease which appeared in the Archives of Otology in 1894 stated that otosclerosis is a "primary disease of the labyrinth capsule." This definition was later affirmed by many writers, such as Neuman in 1913,² by Witmaack in 1922³ and by Drury in 1926.⁴ Modern texts have quite generally accepted this definition and have given it as a basis for the technical description of the disease. For example, Jackson and Coates' text states that "Otosclerosis is a new osseous formation affecting primarily the bony capsule of the labyrinth." Phillips' text states that "The lesion is a spongification of the bone of the labyrinth capsule." Kerrison, however, injects a pessimistic strain in his definition by stating that "Otosclerosis is a lesion originating, *so far as we know*, in the bony capsule of the labyrinth." (Italics by writer.)

It is concerning this definition that the first question arises. Boncour⁵ raised this same question in 1912, when he stated that "Recently doubt has been expressed in various quarters regarding the correctness of the generally accepted definition of Politzer." In order to understand the basis for this definition, a somewhat extensive search was made through the literature to find its origin and the experimental evidence which was the basis for the definition. The wording, except perhaps in Kerrison's text, indicates that the bony changes are confined to the labyrinth capsule. The literature contains many reports concerning microscopic examinations of temporal bones, and the otosclerotic foci are too consistently found in the bony labyrinth to permit any doubt as to their existence. The evidence is, however, not conclusive that these foci are limited to the temporal bone. In fact, this search has failed to reveal, except as noted below, a single instance in which a careful search was made in the other bones of the body for similar foci. Perhaps this search through the literature was incomplete. Granted. On the other hand, the bald statement of the definition that otosclerosis is thus limited in a disease so common among the people of nations who take great pride in their research studies should have unlimited evidence from every angle of approach before a definition so definitely stated should be accepted. The statement of Gimplinger⁶ that "No pathologic changes could be

demonstrated in any other bones" can scarcely be accepted as evidence without a definite statement that a similar microscopic search through the other bones of the body has been made, and his article lacks such a statement.

The available evidence leads one to the conclusion that Kerrison's definition is the true one, and that research, except in certain cases, has not shown that the foci of bony change are limited to the temporal bone. The cases which are cited above as being evidence that the changes are not so limited are much more definite than those stating that they are. Gray's statement⁷ is given without experimental evidence (1906), but he says that "The disease may be found in any other part of the labyrinth capsule, or in other parts of the temporal bone, and possibly sometimes in other bones of the head." Bryant⁸ (1908) limits his observations to the ear but says that "Rarefying otitis of the labyrinthine capsule defines only a local condition of a general pathologic process." Komendantanow⁹ (1914) "Found many points of similarity between the bony changes characteristic of otosclerosis and the bony changes of rachitis." Beck¹⁰ (1912) states that he "Found a great similarity between osteomalacia and otosclerosis." Mayer¹¹ (1914) says that "The bony changes found in otosclerosis so clearly resemble those found by the author in a case of osteitis fibrosa that they must be interpreted histologically as the product of a process analogous to osteitis fibrosa." In the case examined by him he found "The ovaries were atrophied while the hypophysis presented the changes which have been demonstrated in this organ following castration." Ruttin¹² (1922) showed a case of osteopsathyrosis associated with blue sclera which he said showed otosclerotic changes in the ear. Jenkins¹³ (1923) says that "The changes in the long bones (in cases of osteitis deformans) were the same as the changes in the labyrinthine capsule." In some of his cases the diagnosis of otosclerosis had been made during life. Gray,¹⁴ writing again 1928, says that "The disease is a degenerative process involving the organ as a whole."

The negative evidence here cited is obviously taken from cases which present definite macroscopic evidence of gross bony dystrophy. If one can judge from current studies, such evidences are rarely noted among otosclerotic patients, especially in the cases

in the United States. Studies originating in countries where various types of osteomalacia are common, such as India and China, contain little or no reference to the frequency of deafness, and their pathologic reports are concerned, in regard to bony dystrophy, with descriptions of the microscopic appearance of the bones which did show gross bony deformity. No such evidence was apparent, except possibly by deduction, in the cases which were studied for this report, nor could any evidence of familial transmission of such bony dystrophy be secured from patients when their histories were being taken. The three possible exceptions are as follows: One patient reported that her mother who was not deaf had had several fractures from rather insignificant falls; the 7-year-old child of a second patient has had two fractures of the femur from rather trivial falls while playing; but the child had normal hearing; and a third case was being treated for spondylitis at the time the diagnosis of otosclerosis was made. It seems that the evidence presented on both sides of the question is sadly deficient, for in cases in which a diagnosis of otosclerosis was made only the temporal bones were studied, and in cases of obvious bony dystrophy no attention was paid to the condition of the bony labyrinth.

† A second statement concerning otosclerosis which seems to be almost universally accepted and which can be questioned in the light of modern research is that the disease is transmitted by heredity. This important point has been stressed by many investigators. In fact, some otologists will make a diagnosis of otosclerosis only where there is definite evidence of deafness in other members of the family. It cannot be denied that such histories are often secured, but this is not a scientific basis for the assumption that other members of the family had otosclerosis.

The simple fact that the American Otological Society recently sponsored a study of the hereditary transmission of otosclerosis by Dr. Davenport and his associates leads to the conclusion that the society was not satisfied with the evidence in the literature. The American Medical Association sponsored a similar study by Dr. Tinkle. The results of the two studies are not in entire agreement. Davenport¹⁵ says: "The facts so far considered suggest the following hypothesis of the genetic basis of otosclerosis:

Otosclerosis develops under external conditions that favor it whenever the patient has a constitution that combines two dominant factors, as follows: a factor X which lies in the sex chromosome; a factor A which lies in one of the autosomes." Tinkle¹⁶ says: "That deafmutism and otosclerosis are indeed inherited is proved by the study of family histories and identical and fraternal twins just as other traits are studied," and that "The data on otosclerosis may be explained fully on the basis of a single pair of recessive genes." Davenport thinks that otosclerosis is not transmitted as a single entity for he says: "The evidence is good that otosclerosis is only one manifestation of a tendency toward mesoblastic defect." We must conclude, on the basis of these and other studies, that in otosclerosis we have a disease which in certain cases becomes manifest by causing a loss in auditory acuity, which is transmitted in some way by heredity. We cannot conclude that deafness and the well known changes in the temporal bone are the only manifestations of the disease. It is known that otosclerosis can at present be recognized clinically only when deafness of a greater or less degree becomes apparent. It is equally well known that histologically the so-called otosclerotic areas have been found in the temporal bones of patients who had normal hearing immediately before death. Is there then some method of diagnosing this disease in patients who are not hard of hearing? or, to state the question in the words of Davenport, Can we locate and describe some of the other manifestations of mesoblastic defect?

There seems to be, at least in the experience of the writer, a distinct racial trend in the incidence of otosclerosis which has no verification in the literature, but this is perhaps not strange since the studies of otosclerosis have very largely been originated by investigators working with patients from the white race. The two predominant races in continental United States are the white and black. The writer has done functional hearing tests on many patients from both races and in addition has examined the records of many tests done by others, but never has one with the classical picture of otosclerosis come from a patient of the black race. This may be due to limited experience. The American negro of today is a hybrid resulting from generations of inbreeding of the whites and blacks. If otosclerosis is a hereditary characteristic of the

white race, this disease should be apparent clinically in the American negro. The patients of the black race who have been seen by the writer have been from Maryland and Missouri, two of the so-called border states, regions where there is on all hands visible evidence of the inbreeding of the two races, and it would seem that the hereditary characteristics of the white race should be evident in the blacks of this region.

The racial tendency seems peculiar from another standpoint. Some of the physical evidences of undernutrition, such as rachitis, a disease in which the bony changes have been said to resemble those found in otosclerosis, are relatively more common among the blacks. If otosclerosis and rachitis are associated, otosclerosis should appear much more commonly among the blacks than among the whites. These observations may not be in agreement with the experience of others, but such as they are, the statements stand. Some time ago, Dr. Guild of the Otological Research Laboratory of the Johns Hopkins Hospital personally reported that he had found otosclerosis in the temporal bones of one negro man. Other than this personal statement, no evidence as to the frequency of incidence among the negroes is available. The frequent occurrence of osteomalacia among the Chinese and Hindoos is abundantly verified in the literature, but reports as to the relative frequency of otosclerotic deafness are not available. Likewise there is no definite information available as to the occurrence of otosclerosis among the people of the brown race nor from the investigators who are working with the American Indians. It is true that most of the studies of otosclerosis have originated in Europe and America, and consequently these studies are concerned with white patients. This may account for the dearth of information concerning its prevalence among other races. If a trial and error method is to be used in the solution of the problem this is a possible angle of approach.

Fig. 1 shows the results of audiometric tests on three daughters and their mothers. In each case, the daughters were the original patients and when questioned reported that their mothers were hard of hearing. The daughter and mother whose records are indicated by *A* and *B* both undoubtedly have otosclerosis. The typical Bezold triad was secured in the hearing tests, and the Lewis test

for stapes fixation gave the positive response. The history of insidious onset was common to both. There was no history of middle ear inflammation. The mother had paracusis Willisii and slight intermittent tinnitus. She noted the hearing loss when she was about 25 years of age. The daughter first noted the deafness in her right ear about three years before these tests were done, but she did not become alarmed until the loss in the left became noticeable. Assuming that both have otosclerosis, the evidence for the hereditary transmission is definite.

The evidence in Fig. 1, *C* and *D*, is less definite. The diagnosis in the case of the daughter was definite, but in the mother's case was only probable. In the mother's tests, the Bezold triad could not be elicited. She could not hear the c^2 fork by air conduction but could hear it, although considerably diminished, by bone conduction. Her otologist thinks the diagnosis is otosclerosis, although the evidence for the diagnosis is less definite than in the daughter's case.

Fig. 1, *E* and *F*, show the results of the tests on the third daughter and mother. The tuning fork tests in the case of the daughter gave the typical Bezold triad and the Lewis test gave the positive fixation response on each side. Her diagnosis is definite on all points. In the mother's tests, the Rinne was positive on the right side and the c^2 fork could not be heard on the left by bone conduction. (Infinite positive Rinne.) She attributes the deafness in her left ear to injury resulting from the explosion of a firecracker at the time when she was of high school age. The audiometer curve for the right ear is comparable to those secured rather routinely from tests of patients of advanced age. These findings and the history do not eliminate the possibility of the presence of histologic otosclerosis. Clinically, however, if an otologist were to see this case alone, it is not probable that he would make a diagnosis of otosclerosis, since none of the typical results were secured in the hearing tests, and patients with otosclerosis usually give quite typical results in the functional tests of hearing.

These results are shown to illustrate the questionable value of the patient's statement that other members of the family are deaf when the question of heredity transmission is being considered.

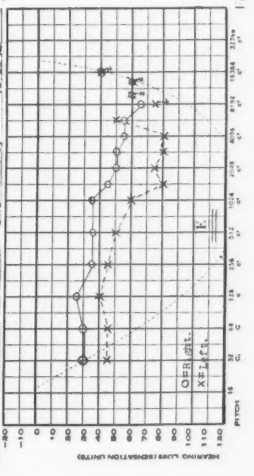
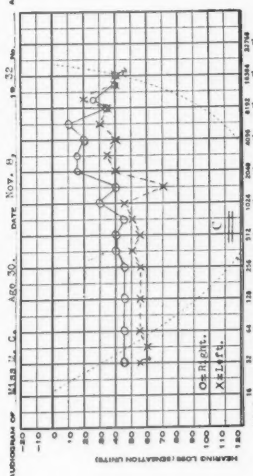
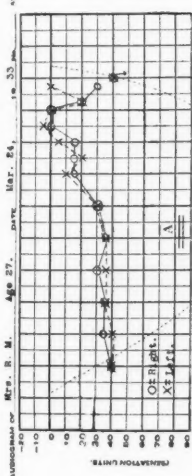
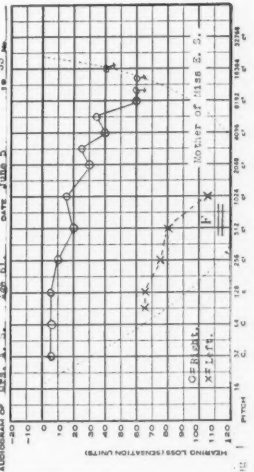
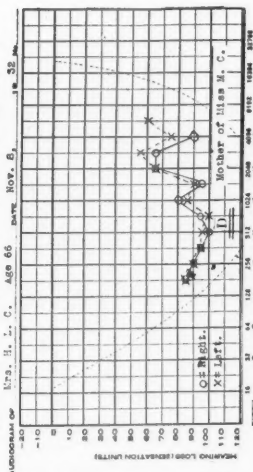
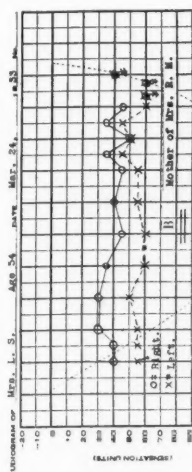


TABLE ONE.

No.	Age Sex	Condition of Teeth	Sensation of Cold	Hereditary	Probability
1.	47 F	Has four impacted third molars.	Requires extra bedding. Always hunting a wrap.	Sister and maternal cousins are hard of hearing.	No deafness in family.
2.	39 F	Wisdom teeth removed because there wasn't room in her jaw.	No trouble in keeping warm.	Paternal aunt hard of hearing.	
3.	13 F	Much dental trouble when small; 8 extracted at one time.	Always complains of being cold.	Father and one sister are hard of hearing.	
4.	33 F	Third molars extracted when she was 22. Teeth are chalky.	Doesn't notice cold as much as others.	Mother quite hard of hearing.	
5.	39 F	Trouble with wisdom teeth.	Difficulty in keeping warm about the house.		
6.	66 F	No note.	No note.	Daughter (No. 5 above) has otosclerosis.	
7.	26 F	One lower molar extracted.	Always cold. Wears extra heavy clothing.	Maternal grandmother hard of hearing.	
8.	35 M	Teeth widely spaced. Wisdom teeth unerupted.	No tendency to be cold.	Paternal grandparents and two sisters hard of hearing.	
9.	37 F	Wisdom teeth unerupted. Much dental caries.	Extra bedding required. Hands always cold.	No deafness in family.	
10.	33 F	Wisdom teeth extracted eight years ago.	Extra bedding required. Cold about the house.	Father deaf in one ear.	
11.	39 F	One wisdom tooth extracted last week.	No note.	Brother hard of hearing.	
12.	52 F	Fourteen teeth extracted about May 1, 1935.	No difficulty in keeping warm.	Maternal grandfather hard of hearing in advanced age.	
13.	21 F	Wisdom teeth present and are apparently good.	Requires extra heat in her room.	No deafness in family.	
14.	31 F	No note.	No note.	Mother hard of hearing after age of 30.	
15.	28 F	No note.	No note.	Mother hard of hearing.	
16.	31 F	Poor teeth. Malformation of wisdom teeth.	No note.	No deafness in family.	
17.	22 F	Wisdom teeth unerupted.	Requires quilts even in the summer time.	Father and two paternal uncles hard of hearing.	
18.	38 F	Teeth poor. Several bridges and partial plates.	Requires sweater when others are warm.	No deafness in family.	

19.	29 F	Teeth are good.	Had five blankets last night and still not warm.	No deafness in family.
20.	26 F	Has two impacted third molars.	Always cold. Requires extra bedding.	Sister has head noises. Mother has otosclerosis.
21.	34 F	Much dental work. All molars have been extracted.	No difficulty in keeping warm.	Daughter (No. 20 above) has otosclerosis.
22.	41 F	No note.	No note.	No deafness in family.
23.	35 F	Two molars have been extracted. Caries.	Tendency to be colder than others.	Father deaf from use of quinine.
24.	50 M	Many teeth are suspicious.	No note.	No deafness in family.
25.	37 M	One wisdom tooth extracted.	Is usually warmer than others.	No deafness in family.
26.	15 F	Considerable dental work. Wisdom teeth unerupted.	Cold when others are warm.	Father hard of hearing from shock during war service.
27.	27 F	Wisdom teeth extracted seven years ago.	Is cold about the house. Requires extra bedding.	Mother deaf in one ear. Maternal grandmother after first pregnancy.
28.	37 F	Many fillings. Wisdom teeth extracted.	Is cold about the house when others are warm.	Mother hard of hearing.
29.	24 F	Wisdom teeth removed because of lack of room.	No note.	Paternal aunt and uncle are hard of hearing.
30.	41 M	Much dental work. One wisdom tooth removed.	Cold about the house when others are warm.	No deafness in family.
31.	37 F	No note.	No note.	Mother hard of hearing. Onset early. Father deaf in old age.
32.	28 F	Teeth are good.	No trouble keeping warm.	No deafness in family.
33.	28 F	Wisdom teeth unerupted.	No trouble keeping warm.	No note.
34.	29 F	Teeth nearly all extracted. Wouldn't hold fillings.	Called "old ear" because she always requires extra heat.	No deafness in family.
35.	38 F	Teeth very poor. Wisdom teeth were erupted normally.	Keeps a shawl in every room of her home.	Mother slightly deaf at age of 60.
36.	33 F	Wisdom teeth extracted. Much dental work.	No note.	Mother hard of hearing.
37.	24 F	Wisdom teeth did not erupt normally. Were extracted.	Requires extra heat in her room.	No deafness in family.

TABLE ONE—Continued

No.	Effects of Pregnancy.	Duration, 25 years or more	Other Pertinent Notes	
			Deafness noted after appendectomy. Under treatment for stomach condition.	Has paracusis Willisii.
1.	No children.	25 years or more		
2.	Became deaf when child was born.	8 years		
3.	Unmarried.	6 months	Mature physical development.	
4.	Deafness noted when first baby was born.	6 years	B. M. R. —10.	
5.	Unmarried.	7 years	Fibritary case.	
6.	Pregnancy did not influence deafness.	30 years	B. M. R. —7.	
7.	Hearing effected during first pregnancy.	1 year		
8.	Male.	2 years		
9.	Two children. Pregnancies had no effect on hearing.	7 years		
10.	Unmarried.	5 years		
11.	Male.	Indefinite		
12.	Two children. Pregnancies did not effect hearing.	9 years		
13.	Unmarried.	4 years		
14.	Hearing poorer after each of three pregnancies.	14 years		
15.	Deafness noted after birth of first child.	2 years		
16.	Hearing poorer after second pregnancy.	2½ years		
17.	Unmarried.	5 years		
18.	Deafness more marked after each of two pregnancies.	11 years		

Perspires very little in the summer.

History of social disease.

Infected by husband.

R. M. R. —10. Ca. 11.5.

Mother has had many fractures. Not deaf.

Diabetic. Cholecystectomy. Cyst removed from liver.

Is allergic to chocolate, milk and feathers.

Has paracusis Willisii.

Epileptic.

Digestive disturbance associated with nausea and vomiting.

Several gall-bladder attacks.

Has paracusis Willisii.

19.	Unmarried.	3 years	Stendyldis. B. M. R. +3 and +5. Blood Ca. 3.8 N. P. N. 21 mg. %.
20.	Two pregnancies. Hearing poorer after each.	4 years	B. M. R. -6, -10, -2, +8, -22, -11, -7, -7, -1.
21.	Deafness not associated with pregnancies.	25 years	Has paracusis Willisii.
22.	Two pregnancies did not effect hearing.	24 years	Has paracusis Willisii.
23.	Two children. Pregnancies did not effect hearing.	13 years	B. M. R. -1.
24.	Male.	4 years	Has paracusis Willisii.
25.	Male.	12 years	Has paracusis Willisii. An aviator.
26.	Unmarried.	4 years	Advanced physical development.
27.	No children.	15 years	Thyroid dystrophy from history. Mother has pellagra.
28.	Unmarried.	17 years	Has paracusis Willisii. B. M. R. -19 and -7.
29.	One child. Pregnancy had no effect on hearing.	4 years	
30.	Male.	8 years	B. M. R. -3.
31.	No note.	10 years	B. M. R. -4.
32.	Unmarried.	1 year	
33.	Unmarried.	1 year	B. M. R. +8. Pelvic operation one year ago. Excessive menstruation.
34.	Four children. Hearing poor after first childbirth.	5 years	B. M. R. -2.
35.	One child. Hearing poorer after childbirth.	15 years	
36.	Two pregnancies. No effect on hearing.	12 years	History of thyroid medication for 6 years.
37.	Two pregnancies. Both made hearing poorer.	2 years	Pelvic operation in past.

It may be made with complete truth and honesty, but it is only by careful clinical examination that definite information can be secured. This objection applies especially to investigations in fields allied to otology by those who do not have a clear conception of the nature of otosclerotic deafness. In this study, with careful questioning and clinical tests where possible, evidence of the hereditary transmission was secured in 70 per cent of the cases. (See table 1), but verification of the patient's statement was possible in only a few.

In order that the progress of otosclerotic deafness might be more fully understood, it has been possible to make two or more tests on twenty of the patients which have been studied. Fig. 2 illustrates the progress of the deafness in a woman who was tested twice with twenty-eight months intervening between the time of the two tests. The tests were made under different conditions. Only the last was made in the soundproof room. Consequently the loss is greater than indicated by the two records. Subjectively her deafness has become sufficiently marked that she is now shut out of much of her social life. The two curves do not indicate that the loss has progressed markedly, but when the conditions of the two tests are considered, the loss in both ears seems to be definite and for all tones of the audiometer range and is greater in the left than in the right ear.

This record should be compared with that shown in Fig. 3. This second patient was first seen in July, 1932, and was instructed to return at once if she noted any progress of deafness. Two months later she noted further loss in her left ear which up to that time had been considered quite good. The additional loss is for almost all tones in the left ear. The hearing in the right had remained stationary.

This patient was sufficiently cooperative that it has been possible to secure records of some forty tests since that time. The results are illustrated in Fig. 4. At the top of the chart have been tabulated the variations in her threshold determinations in these tests. For example, the threshold for the tone 512 d. v. in the right ear has varied from 25 sensation units (s. u.) to 45 s. u., but approximately 80 per cent of the thresholds were either 35 or 40 s. u. It is not possible to state whether this is an average

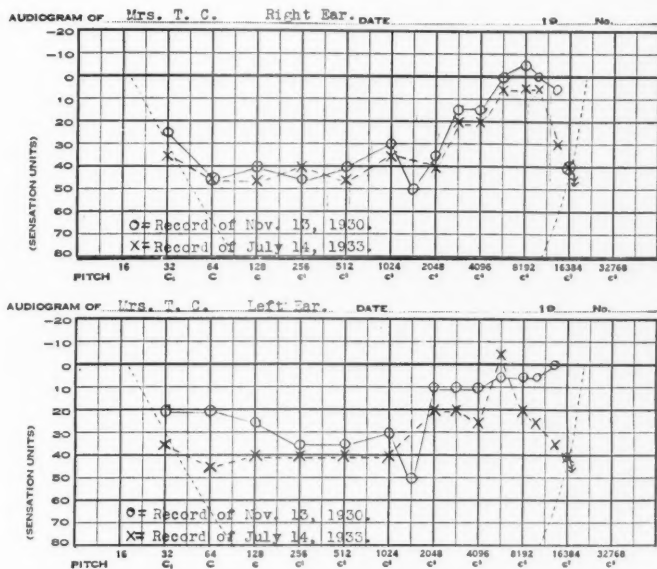


Fig. 2.

fluctuation which one would receive from repeated tests of any ear case or not. Statistically, it seems that such records might be secured from tests on any patient, for if the thresholds for any one tone were plotted in a curve they would show quite a normal distribution. On the other hand, patients with otosclerosis who are questioned often state that their acuity fluctuates from time to time. This may be true, but the records in this case do not corroborate the statement. Often when this patient thought her hearing was poorer, the results of the tests would not correspond with her statement. At the bottom of the chart are two records taken under identical conditions with fifteen months intervening. A comparison of the two shows definitely that there has been no further progress of the deafness during that time.

Fig. 5 shows another manner in which the progress of the deafness must be considered. The record at the top of the chart was secured from a woman, 27 years of age, whose deafness had been noticed for fifteen years. (See No. 27, table 1.) At the

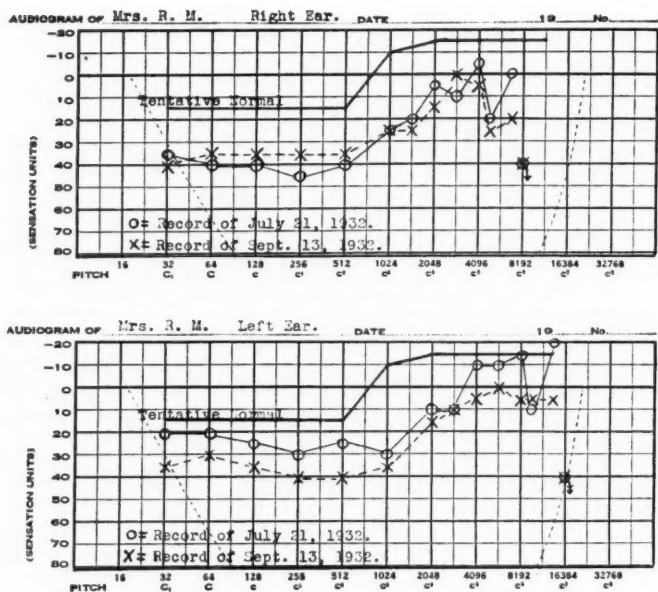
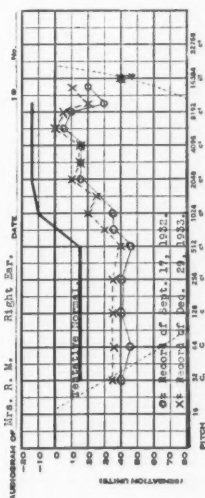


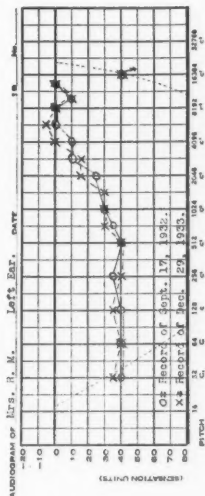
Fig. 3.

bottom of the chart is the record of a young girl, 13 years of age, whose deafness had been noted for but six months. (See No. 3, table 1.) The two records indicate approximately the same loss in acuity. Just why the loss in the case of the young girl should relatively be so great in such a short time is difficult to understand. Repeated tests show that her deafness has not progressed during the eight months in which she has been under observation since the first test.

The greatest loss in acuity found in any case except that shown in Fig. 1 *D* is illustrated in Fig. 6. This record was secured from a man whose deafness had been noted for fifteen years. The patient died shortly after these tests were made, of generalized torula of the brain, and the typical otosclerotic bone changes were found in the microscopic examination of the temporal bones. These are also evidences of rather widespread pathology in the cochlea,

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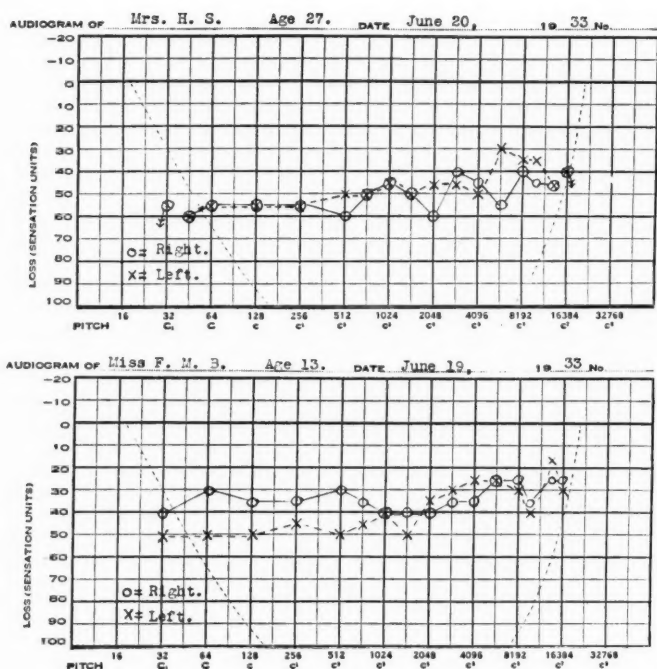


Fig. 5.

making it impossible to determine what part of the deafness was caused by each of the two superimposed lesions.

Drury¹⁷ (1926), after a thorough general physical study of otosclerotic patients, reported finding frequent evidence of endocrine disturbances. His study did not reveal any one gland alone as being responsible for the disturbances. The present status of endocrinology is admittedly far from being a closed book, and the possibility of some endocrine disturbance being a factor in the causation of otosclerosis cannot be overlooked. The patient whose record is shown at the top of Fig. 5 had this pertinent note in her history. (See No. 27, table 1.) A year before the first test was made she was confined to her bed and was said to have had an overactive thyroid and was under iodine treatment for one

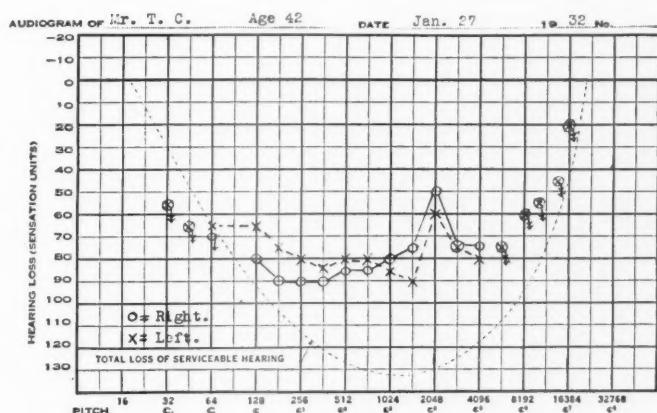


Fig. 6.

month. The 13-year-old girl (See No. 3, table 1.), whose record is shown at the bottom of Fig. 5, had the physical development of one much older, but the members of the medical staff could locate no glandular dystrophy. The basal metabolism rate of the cases in which this function was studied was usually within normal limits. The woman whose records are shown in Fig. 4 had a temperature curve which varied from 95 or 96 degrees in the morning to normal at night, is below weight for her height and age and has been carefully studied for evidence of glandular dystrophy and tuberculosis but no symptoms other than these have been found.

Davenport,¹⁵ in his study of heredity, has pointed out the frequency of defective dentition in patients with otosclerosis. In a personal communication he states that in making inquiries as to the condition of the teeth he was attempting to ascertain if the teeth could have caused sinus involvement which might in turn have affected the ears. Defective dentition in otosclerotics has been noted by other investigators. One states that these patients come to the otologist only after they have spent all their money on teeth repair. In this study an attempt was made to determine the opinion of the patients as to the condition of the teeth. Eighty per cent of those who were questioned (see table I) replied that

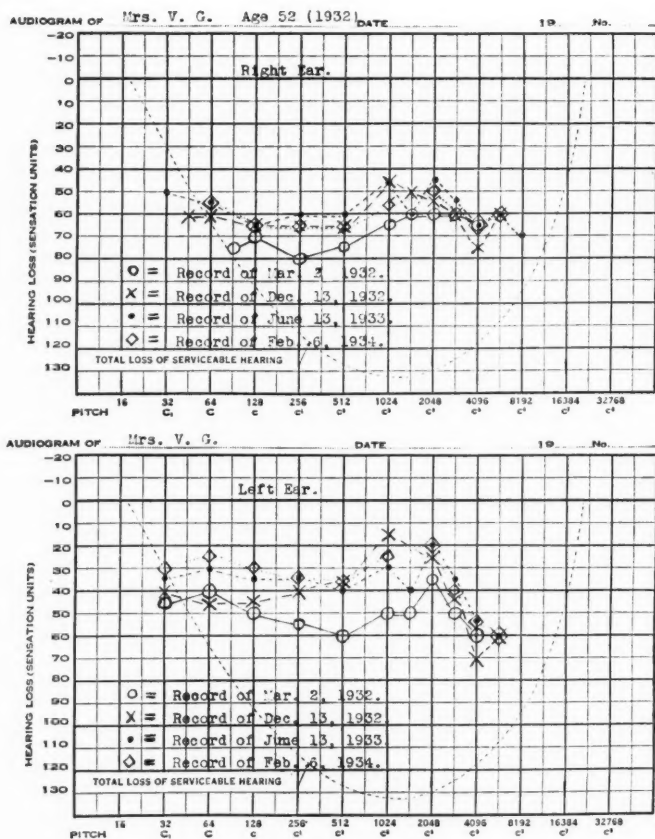


Fig. 7.

there was marked dental trouble, usually in the form of impacted third molars or "chalky" teeth which would not hold fillings. No evidence could be found in the dental literature to determine if this percentage exists among persons without otosclerosis.

A large number of patients reported feeling cold when others around them were warm. The patient whose record is shown in Fig. 4 was carefully studied in Barnes Hospital during the last days of September and the first days of October, the season dur-

ing which the climate in St. Louis is considered delightful. At night while in the hospital she required extra bedding and hot water bottles in order to be made sufficiently comfortable so she could sleep. (See No. 20, table 1.) Another patient reports that at home she has a shawl in every room so that one will always be available. This symptom was reported by 60 per cent of the patients (see table 1) who were questioned. This was thought to be a new observation but was found to have been reported by several others.

Childbirth is often considered to have a deleterious effect on the hearing of otosclerotic mothers. It has been possible to study this symptom only by questioning. Of eighteen women who had been pregnant, 72 per cent reported that during pregnancy, the puerpium or lactation their deafness had become definitely more noticeable. (See table 1.) It has not been possible to determine which of the three phases adversely affects the hearing. Such information can only be secured by accurate tests over a long period of time.

Definite improvement of hearing in cases of otosclerotic deafness is rarely reported. It is generally assumed that once the otosclerotic process has become firmly established, changes in acuity for the better are impossible. Crockett,¹⁸ however, reported to the American Otological Society, in 1932, three cases of otosclerosis who, while under treatment, showed definite improvement in hearing. The duration of the deafness was less than twelve months. Lewis¹⁹ in the same meeting reported improvement in two cases of "fixation" deafness in which the duration had been many years. These cases of improvement are difficult to understand in the light of our present conception of otosclerosis. Hypothetically, the improvement might be explained on the basis of two independent and coincident lesions, both having a deleterious effect on hearing, one of which might respond to treatment with a resulting improvement in hearing. If such a hypothesis could be assumed, the improvement in some of these cases might be understood. In cases where two such lesions are known to exist, it is not possible with our present knowledge to determine just what amount of decrease in acuity is caused by each of the coincident lesions. The improvement shown in the

case illustrated in Fig. 7 may be explained by such an assumption. (See No. 12, table 1.)

This patient was first seen as a clinical case on March 2, 1932, and a diagnosis of questionable otosclerosis was made by one of the junior members of the otolaryngologic staff. Unfortunately, there is no note on her clinical history that this diagnosis was confirmed by one of the seniors. She had been a known diabetic for seven years. A short time later she entered Barnes Hospital for instruction as to diet regulation and insulin dosage. She left the hospital in a few days with the diabetes well under control. She returned April 3, 1932, on account of severe pain in the epigastrium and a diagnosis of cholecystitis was made. On account of an attack of acute tonsillitis, the gall bladder operation was delayed until May 2, 1932. At the operation the gall bladder was removed as well as a cyst in the liver about the size of a lemon. Her recovery was uneventful. On September 2, 1932, her tonsils were removed. Since then her teeth, which were badly in need of attention, had been cared for in the Washington University Dental Clinic. This whole picture is quite complicated if one considers the hearing alone. The basis for conclusions as to changes in hearing ability resulting from the various operations is shown in the results of the audiometric tests which have been repeated from time to time. These indicate a slow and gradual improvement, especially in the left ear, during the entire time she has been under observation. Between March 2, 1932, and December 15, 1932, there was also definite improvement in the acuity of the right ear. On February 6, 1934, the patient was seen for otologic examination by Dr. L. W. Dean on account of the interest this case had aroused. He pronounced the drum membranes perfectly normal in contour and color, and found that the ossicles moved normally as seen with the Siegel's otoscope, and expressed his opinion that the diagnosis at that time was uncomplicated otosclerosis. All treatment which she had received was instituted to improve her physical condition. Nothing was done for her ears. Subjectively the patient says that her hearing is much improved, that she can converse easily with her children and is happy that she can hear the falling raindrops and the singing of birds.

It will be noted in the audiometer records that the improvement has been largely for tones below 4096 d. v. The greatest loss is for high tones and no recovery is evident for these. The greater loss for high tones than for low suggests that there is present a combined conductive and perceptive lesion. Since the improvement has been for tones at the lower end of the tonal range, it seems that if this is a combined lesion the improvement has come in the conductive rather than in the perceptive element.

Table 1 has been prepared to show in detail some of the symptoms other than deafness which have been obtained by questioning these patients. Details as to individual audiometric measurements have been omitted for obvious reasons.

There is a marked preponderance of females in the group. This is probably due to the fact that the number in the group is small, although most investigators agree that otosclerosis occurs more frequently in women than in men. Other symptoms which have not been considered may be more common than those tabulated. Questioning a patient may subconsciously cause some insignificant symptom to become predominant in the patient's mind and all of these may be of little consequence. None of the patients considered himself ill. All were able to go about their regular duties under the handicap of deafness. The facial appearance of "apprehension" which is often evident may be a psychic development resulting from deafness. On the other hand, when the confidence of these patients has been secured and they understand that the questions are asked in order to learn about the general physical health, even though they have apparently no bearing on the deafness for which they seek relief, uniformly give the examiner the impression that they are not physically well.

Comment.—The usual methods of examination have been followed in classifying these cases as otosclerosis. The Bezold triad was uniformly secured in the hearing tests. There was no history of otitis media, suppurative or nonsuppurative, nor was evidence of previous middle ear inflammation secured by the otoscopic examination. The appearance of the tympanic membranes, the movements of the ossicles as viewed through the otoscope, the condition of the eustachian tubes, the tuning fork tests and all the other usual clinical indications for a diagnosis of otosclerosis

have been carefully investigated. The selection of the cases may be open to criticism because all were not seen by the same otologist. Many were private patients referred by members of the staff of the Department of Otolaryngology.

This report is not presented as a completed study. Definite conclusions cannot be drawn. The evidence presented will be of much greater value when it is compared with the information secured by following these patients over a long period of time and with that secured from similar patients. It appears that a great deal concerning the nature of the progress of otosclerotic deafness can be learned by frequent tests and a careful study of the general physical condition of these patients. The interest in the problems of otosclerosis should not be confined to microscopic studies. The real problem is a clinical one.

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XXVII.

AN ANALYSIS OF THE EFFECTS OF REPEATED
BODILY ROTATION, WITH ESPECIAL REF-
ERENCE TO THE POSSIBLE IMPAIR-
MENT OF STATIC EQUILIBRIUM.*

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I.

It has long been recognized that whirling dancers, figure skaters, acrobats and other persons who frequently engage in continuous bodily rotation are immune to the visual vertigo (i. e., the illusory movement of the environment) which is ordinarily experienced after prolonged turning by persons not accustomed to motion of this character. Moreover, as early as 1820, Purkinje³⁶ demonstrated that there is, in general, a strict correspondence between the direction, duration and intensity of this subjective phenomenon and the direction, duration and vigor of the peculiar oscillatory eye movements comprising postrotational nystagmus. It was not, however, until 1906 that Ruppert³⁸ observed what might have been reasonably predicted on the basis of information available for decades, namely, that persons who have acquired immunity to vertigo through repeated turning also show little or no postrotational nystagmus. In the same year Abels¹ showed that the nystagmus of pigeons can be greatly reduced by subjecting them daily to successive periods of passive rotation, and upon the basis of this experimental substantiation of Ruppert's observation, he concluded that the disappearance of vertigo in human subjects who repeatedly engage in bodily rotation is a direct result of a corresponding reduction in nystagmus. This latter effect Abels believed to be dependent upon a "central" neural process which he referred to simply as "habituation" (*Gewöhnung*).

*The experimental results reported in this paper were obtained while the writer was a National Research Fellow at Northwestern University (1932-33).

During the years just prior to 1906, Dr. Robert Bárány had been endeavoring to demonstrate the usefulness of postrotational nystagmus as a clinical index to the functional and structural integrity of the vestibular apparatus of the inner ear, and he was therefore not slow to appreciate the implication of the observations reported by Ruppert and Abels: if postrotational nystagmus was indeed susceptible of extinction or even substantial reduction by means of repeated elicitation and if this type of response modification was not dependent upon demonstrable injury to or pathologic change in the vestibular receptors or associated neural pathways, then the diagnostic significance of nystagmus would be equivocal and its reliability and clinical usefulness correspondingly diminished. Although he acknowledged the immunity of practiced dancers to vertigo and also readily accepted the reliability of Abels' observations upon the experimental reduction of nystagmus in pigeons, Bárány did not believe, however, that the development of immunity to vertigo was accompanied in human subjects by a reduction in nystagmus (the observation of Ruppert notwithstanding).

"We must not forget," says Bárány,⁴ "that head nystagmus [which is manifested by pigeons] does not exist in men and that the results of this [Abels'] investigation are therefore not transferable to men. Consequently it was important to study the effect of habituation in men. I myself have made such a study with a single subject and for fourteen days have rotated him every day fifty or sixty times in the revolving chair. No effect upon the duration of the after-nystagmus was to be observed."

Although in an earlier publication Bárány³ himself had recognized the intrinsic connection between vertigo and nystagmus, he now denied the existence of any such relationship and advanced the hypothesis that these two phenomena might vary independently. On the basis of this supposition he concluded that in consequence of repeated bodily rotation, "only the subjective accompaniments of nystagmus become unnoticeable, while the nystagmus itself shows no significant weakening."⁴ By virtue of Bárány's professional eminence and his enviable reputation for accurate scientific observation, this dictum was widely accepted by his colleagues; and the duration of the ocular nystagmus produced

by a standardized rotational stimulus attained wide popularity as a test of the normality of the nonacoustic labyrinth. It was not, in fact, until more than a decade had elapsed that the doctrine of the "normal invariability" of nystagmus, upon which the justification of the rotation test depended, was called into question and the diagnostic reliability of the test itself subjected to critical analysis.

When the United States entered the World War in 1917, the Bárány nystagmus test was immediately introduced as a device for determining the potential flying ability of candidates for the American Air Service.^{2 21 26} However, after this test had been in use for several months, a group of psychologists then connected with the Medical Research Laboratory at Mineola, Long Island, discovered that veteran flyers, who had undergone extensive bodily rotation in connection with either "stunt" or "combat" flying, frequently showed a nystagmus considerably briefer than the minimum required of candidates for admission into the service.^{9 26} This finding immediately precipitated a bitter controversy; but it also stimulated several careful experimental studies,⁸ the results of which have decisively indicated that the nystagmus of both men and animals is indubitably susceptible of conspicuous reduction or, in some cases, of complete abolition by means of repeated bodily rotation.

II.

The question which now presents itself is this: Does the demonstration of the susceptibility of postrotational nystagmus to radical reduction by means of repeated elicitation necessarily invalidate the Bárány test? The answer to this question depends, obviously it seems, upon the answer to a second query, namely: What is the nature and organic locus of the change which is responsible for the nystagmus reduction? If, on the one hand, it can be shown that this type of response modification is uniformly accompanied by injury to or structural alteration of the vestibular receptors, then the Bárány test will be validated and its usefulness confirmed. If, on the other hand, it can be demonstrat-

*These studies have been reviewed in a recent monograph by the writer.³²

ed that the reduction of postrotational nystagmus through repetition is dependent upon a "functional" change occurring within the central nervous system, then it will be apparent that the duration of postrotational nystagmus cannot afford an entirely reliable indication of the normality or abnormality of the vestibular receptors.

In 1922, Maxwell, Burke and Reston²⁷ reported an investigation in which rabbits, whose nystagmus had been reduced by repeated bodily rotation, were found to give a normal response to caloric stimulation. To quote:

"Our experiments show that daily rotation of the rabbit reduces, in some cases very markedly reduces, the after-nystagmus. We have attempted by the caloric test to discover the functional state of the labyrinth at the close of the series. We have no reason to believe that the animals have been injured by the amount and rate of rotation [one revolution in two seconds] to which they have been subjected. It is true that Wittmaack (1909) has reported and de Kleijn and Magnus (1920) confirmed the statement that rotation (centrifugalization) at a high rate of speed [33 revolutions per second] can produce destructive changes in the labyrinth.* But the latter observers have used even this high speed to differentiate between the canals and the otoliths, since only the otoliths are injured by this means. Now in our experiments we are dealing with reactions to rotation in the plane of the horizontal canals, in which we believe the ampullæ of the horizontal canals are mainly and the otoliths possibly not at all concerned. . . . We believe the results warrant the assumption that no injury has been done but that through habituation the organism has been rendered less responsive."

In 1925, Dunlap¹⁰ reversed the procedure used by Maxwell, Burke and Reston and investigated the effect of repeated caloric stimulation upon the sensitivity of rabbits to bodily rotation. He also arranged his experiment so that it would indicate whether the effect of repeated caloric stimulation is specific for the ear stimulated or whether the sensitivity of the other ear is also affected. It was found that daily irrigation of the left ear pro-

*Cf. Hasegawa,¹⁸ 1931.

gressively shortened the nystagmus elicited by this type of stimulation and at the same time produced a marked reduction in the duration of the nystagmus elicited by subsequent irrigation of the right ear. In this connection Dunlap says:

"From the marked effect on the right ear nystagmus by left ear irrigation, it is fairly obvious that the adaptation produced by the irrigation was not entirely 'peripheral'; that is, it was not an effect on the receptors or other mechanisms within the semicircular canals or vestibules of the ear on the side irrigated; but was in part 'central,' that is, it was an effect on the nervous mechanisms connected with both ears."

Later in the experiment, after both ears had been subjected to repeated caloric stimulation, the rabbits were tested for post-rotational nystagmus. The results were such as to lead Dunlap to the conclusion that "Obviously, the caloric stimulation had produced a certain adaptation to rotary stimulation also."

A year later, Gould¹³ made a detailed histologic study of the labyrinths of rats in which nystagmus had been reduced by means of repeated rotation. In regard to his findings, he says ". . . it early became apparent that a possible structural basis for the abnormal reactions reported must be sought elsewhere than in injury to or abnormal development of the parts of the vestibular ear."

The most recent experimental attack upon the question of whether nystagmus reduction by means of repeated bodily rotation is dependent upon vestibular injury has been made by Fearing and Mowrer.¹¹ These writers report that if pigeons, while under deep general anesthesia, are subjected to repeated bodily rotation (sufficient in intensity and extent to produce a 50 or 60 per cent reduction in the nystagmus of unanesthetized pigeons), no reduction whatever is to be discovered in the nystagmus elicited by subsequent rotation of these birds under normal physiologic conditions.

It is thus evident from the highly consistent results of the widely varied types of experiments just reviewed that the reduction of nystagmus by means of repeated bodily rotation (at moderate speeds) is definitely not dependent upon any detectable form of injury to the vestibular receptors. It is clear, therefore, that

the duration of postrotation nystagmus does not provide an entirely unequivocal index of the soundness of the vestibular receptor mechanism. Thus, if a person passes the nystagmus test (administered with all due precautions), he may be said, with a certain degree of confidence, to have normal vestibular receptors; but if he fails to pass the test, no definite conclusion can be drawn from the results of the test itself.* More than a quarter of a century ago Wintermute³⁹ warned against the naïve interpretation of the absence or unusual brevity of nystagmus as a certain indication of pathology in the vestibular receptors; such a finding, he said, must always be viewed in the light of the patient's previous rotational experience. The experimental findings reviewed above seem to emphasize the importance and correctness of this point of view.

III.

Since the reduction of nystagmus occasioned by repeated bodily rotation is evidently not due to demonstrable injury to or structural alteration of the vestibular receptors, the most plausible alternate assumption is, as earlier suggested, that this type of response modification is dependent upon some sort of "functional" change in the central nervous system. The precise nature of this change can at present only be conjectured. However, an important step toward its understanding will have been made by obtaining a satisfactory answer to the following question, namely: Is nystagmus the only vestibular response affected by repeated bodily rotation, or is there a general diminution, under these circumstances, of *all* vestibular phenomena?

The supposition that visual vertigo is directly dependent upon the eye movements comprising postrotational nystagmus and that any variation in the one is necessarily accompanied by a corresponding variation in the other has been substantiated experimentally by Griffith,¹⁷ who says:

*On the basis of recent clinical reports it is likewise to be inferred that the former hope that the nystagmus test might also prove to be a virtually infallible guide in the diagnosis and localization of intracranial lesions and tumors (see Jones,²¹ 1918) has not been realized. The studies of Shuster,³⁸ reported in 1933, seem particularly relevant in this connection.

"[In consequence of repeated rotation every subject] shows more or less decrease in the duration of nystagmus, in the number of ocular movements, and in the time of apparent movement in the visual field [visual vertigo]. It will be noted that the three representative values decreased together. The decrease in duration of nystagmus varies from 29 per cent. in the case of subject I, to 100 per cent. for subjects E, G, H, K, L, O, and P. The average amount of decrease in all [sixteen] subjects . . . turns out to be 79 per cent or more than three-fourths of the initial time. Furthermore, there is every reason to believe that had the several series been continued sufficiently, all subjects would have decreased 100 per cent."

It has commonly been assumed that postrotational nystagmus and the concomitant illusion of bodily turning in the direction opposite to the preceding actual rotation, which is ordinarily experienced when the eyes are kept closed, represent "two distinct phenomena,"^{21 20 13} However, considerations advanced by Holt¹⁹ and others indicate, on the contrary, that just as the illusory rotation of the environment which occurs when the eyes are open is dependent upon the *visual* consequences of postrotational nystagmus, so likewise is the illusory rotation of the subject's own body which occurs when the eyes are closed very probably dependent upon the *kinesthetic* and *tactual* consequences of the nystagmus.* Although crucial experiments have not yet been carried out in this connection, it seems safe to predict that any reduction produced in postrotational nystagmus by means of repeated passive bodily rotation will be found to be accompanied by a corresponding reduction in the postrotational illusion of bodily turning.

*The evidence now available seems to indicate that there are no true vestibular sense data of any kind; all of the subjective phenomena which are known to follow vestibular stimulation are probably exclusively dependent upon the stimulation of other types of receptors, occasioned by the occurrence of vestibularly elicited reflexes. The facts of neurology support this point of view and agree with the results of psychologic experimentation. After mentioning the three neural tracts (to be referred to later) which are known to emerge from the primary vestibular nuclei in the medulla, Ranson³⁶ remarks that "No tract to the thalamus is known, a fact which is in keeping with this other, that ordinarily the activities of the vestibular apparatus are not clearly represented in consciousness."

Griffith¹⁷ has reported that with repeated bodily rotation the response commonly designated as "past-pointing" diminishes in magnitude and finally disappears; and the present writer has become convinced, through certain casual observations, that the so-called "falling reaction" behaves in the same manner. Of the past-pointing and falling reactions, Griffith says: "Both of these tests depend upon systemic [sic] innervations from the end organs in the canals." And in support of this connection Griffith cites Dr. I. H. Jones,²¹ who, however, explicitly states that

"[Past-pointing] is a cerebral motor act. Neither turning a person in a chair nor douching his ears causes him to past-point. *He is asked to raise his arm and then bring it back to find the finger [of the examiner]. Before ear stimulation he is able to find the finger; after ear stimulation he is unable to find the finger because of vertigo.* It may be regarded as a law of the ear-tests that where *there is no vertigo there is no past-pointing.* Vertigo is the primary reaction; past-pointing is a secondary manifestation." (p. 187.)

After citing numerous arguments in support of the foregoing contention, Jones continues:

"It may be noted at this point that the phenomenon of 'falling' after ear stimulation may be regarded as a past-pointing of the entire body. The patient falls because of the vertigo, and not because his body is drawn to one side or the other by ear stimulation." (p. 203.)

Granting, then, that both past-pointing and falling are due to the postrotational illusion of bodily turning and that the latter, in turn, is dependent upon the kinesthetic and tactual consequences of nystagmus, it becomes intelligible why both past-pointing and falling disappear with repeated rotation: they are secondary consequences of the postrotational nystagmus and therefore diminish as the nystagmus diminishes.

It has been assumed by many writers in the past that the nausea, profuse perspiration, vasomotor changes, and certain other organic effects of bodily rotation are due to direct nervous connections between the labyrinth and various visceral mechanisms. Although it is not certain that such connections do not exist, their

presence has not yet been demonstrated. Moreover, since all of these effects can be produced by purely visual stimulation²⁹ and since they disappear as the subject becomes accustomed to repeated bodily rotation,¹⁷ it seems most natural to infer that the organic and visceral disturbances just mentioned are dependent upon the visual, kinesthetic and other sensory consequences of nystagmus rather than upon impulses passing directly from the vestibular apparatus to the organic mechanisms involved in these disturbances.

The foregoing considerations seem to lead to the conclusion that of the various sensory and motor phenomena which ordinarily follow continuous bodily rotation in the horizontal plane, nystagmus alone is primary, in the sense of being a direct result of vestibular stimulation; all of the remaining effects—visual vertigo, bodily vertigo, past-pointing, falling, nausea, etc.—are apparently due, directly or indirectly, to the stimulating effects of the nystagmus and for this reason tend to be modified by repeated bodily rotation in a manner parallel to the way in which the nystagmus is affected.

IV.

Since all of the postrotational phenomena considered above are incapacitating in one way or another, some question may naturally arise as to the biologic utility of the sensorimotor mechanisms which are responsible for their occurrence. Certain it is that many of the more spectacular feats of acrobats, dancers, athletes and skaters are impossible until the performer has overcome through frequent repetition the usual effects of prolonged bodily turning. The same is likewise true of exhibition riders in the so-called motorcycle dromes.³³ Why aeroplane pilots—particularly "stunt" and "combat" pilots—should ever have been expected to show the usual responses of naïve subjects to bodily rotation is a most perplexing problem. As pointed out by Griffith,¹⁶ the most logical deduction from the premises of those who insisted upon this singular requirement would necessarily have been that "the successful and safe flier is the one who comes out of a spin with his visual fields so confused by the resulting ocular movement (not to mention all the other distressing effects of

turning) that he must escape destruction only by a miracle." It is perhaps a hopeful sign that the rotation test is now generally used in aviation only as a means of convincing the student pilot that it is safer to rely upon his navigating instruments than upon his "instincts."³⁴

However, in attempting to reach an understanding of the after-effects of bodily rotation and of the influence of repetition upon these phenomena, it is important to keep clearly in mind the fact that prolonged bodily turning is a biologically unusual and essentially abnormal type of stimulation and that the reactions thus produced are correspondingly abnormal and unindicative of the action of the vestibular apparatus under the more ordinary conditions of life. The natural function of the vestibulo-ocular reflexes involved in the nystagmus produced by prolonged rotation has been discussed in an earlier paper²⁸ and will not be further considered here, except to say that these responses do important service in the facilitation of efficient vision. All other known vestibular reflexes appearing under ordinary conditions of stimulation are subservient to the maintenance of normal bodily orientation with reference to the direction of gravity. It is now important to examine the available evidence regarding the effect of repeated bodily rotation upon these latter, the so-called equilibrium reflexes.

Persons who have served as subjects in nystagmus reduction experiments have occasionally complained of more or less permanent impairment of equilibrium, the development of which they have been inclined to attribute to their previous rotational experiences. Brammer⁵ has examined the ability of experienced aviators to stand motionless with vision excluded and "with heels together and toes extended at an angle of 45 degrees" and has found that "pilots do not differ materially from the nonflyers in scores attained," this notwithstanding the fact, as indicated by earlier studies,³⁵⁻⁹ that the repeated turning and spinning involved in flying significantly reduces vestibular nystagmus. Likewise, whirling dancers, acrobats and other individuals who frequently engage in prolonged active bodily rotation commonly show a distinctly subnormal nystagmus,^{4, 32-40} but are not known to suffer any impairment of equilibrium (quite the contrary!) It would seem

probable, therefore, that the alleged equilibratory disturbances reported by the experimental subjects referred to above were largely imaginary or, if real, due to causes totally unrelated to the repeated rotation to which they had been subjected, although the matter certainly cannot be finally decided upon the basis of the evidence just described.

In 1920, Griffith¹⁴ reported an experiment in which the nystagmus of a group of white rats was reduced—in certain individuals completely extinguished—by means of repeated rotation. "All subjects," says this writer, "were tested for equilibrium after a series [of rotations] had been completed; and all responded to being thrown and dropped just as alertly as before rotation." Due to the unrefined nature of the test used by him and his failure to eliminate vision (which may alone suffice to elicit highly efficient righting responses), Griffith's observations, however suggestive, can scarcely be regarded as definitive. Somewhat later in the same year, Griffith¹⁵ reported a second study in which rats, which had been subjected to uninterrupted rotation at a uniform speed for a period of some months, subsequently showed unmistakable evidence of permanent disturbances of equilibrium and locomotion. Detlefson⁷ has since pointed out, however, that these effects were very probably due to a specific ear infection, the contraction of which was presumably wholly unrelated to the repeated rotation as such. Moreover, Dorcus⁸ has recently performed an experiment similar to that of Griffith and has concluded on the basis of his findings "that continuous rotation at the speed used [one revolution per second] did not produce any disturbance in the muscular system, nor did it produce any disturbance of equilibrium." But here, again, equilibrium was tested only by casual observations. The need for further and more refined experimental inquiry regarding the possibly injurious effects of repeated bodily rotation upon equilibrium is thus clearly indicated.

V.

The perching proclivity of birds, which necessarily involves a more acute type of static equilibrium than ordinarily required of mammals and other creatures, seemed to make them especially suitable subjects for an investigation of the foregoing problem.

After some preliminary observations had been made, it became evident that a freely turning wooden perch would afford a very satisfactory device for testing the equilibratory ability of avian subjects, providing that some means of accurately recording the rotary movements of the perch produced by the bird in attempting to maintain its balance could be developed. The apparatus finally devised for this purpose has been described in detail elsewhere³⁰ and will not be discussed here, except to say that it was virtually noiseless in operation, worked smoothly and easily, and recorded the clockwise and counter-clockwise movements of the perch independently on two (Veeder-Root) counters, with an error con-

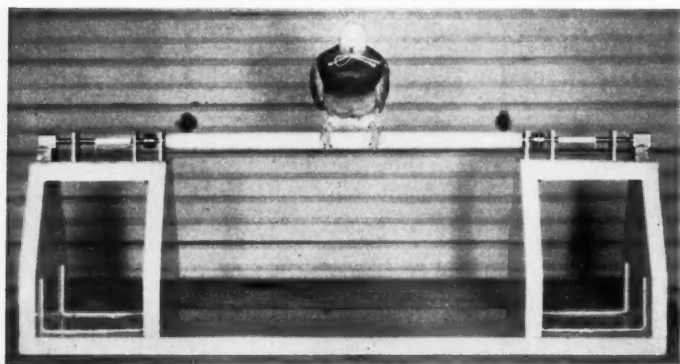


Plate 1.

sistently less than 1 per cent. Plate 1 shows the perch and recording apparatus which were used in the experiment about to be described.

Because of the convenience in keeping and handling them and because of the wide variety of studies previously reported concerning their vestibular responses in general, pigeons were selected as subjects in the present investigation. The first group of birds, which consisted of ten healthy, adult homers, was subjected to the following routine: Each bird was hooded and held immobile by means of a cloth wrapper for ten minutes in order to allay excitement (Cf. Mowrer³¹). The bird was then carefully freed from the cloth (but not unhooded) and placed on

the perch (which was securely locked in position by means of a device not shown in the illustration) and allowed to remain thus, entirely undisturbed, for one minute. At the end of this time the perch was gently released and the bird was allowed to balance for thirty seconds. A thirty-second rest period was then allowed, during which interval the perch was firmly locked in position. Then followed another thirty-second period of balancing, then another rest period, and so forth until the bird had completed ten balancing performances.* After each thirty-second period of balancing, the counters at the opposite ends of the perch were inspected and the amount of clockwise and counter-clockwise movement recorded to the nearest tenth of a revolution. The routine just described was carried out between 7:30 and 11:00 o'clock on four successive evenings for each of the ten birds.

On the day following the fourth perching test, the ten birds were subjected to twenty periods of bodily rotation in the mesial plane at the uniform rate of one revolution per second, with sudden acceleration and retardation; and this procedure was repeated daily for two weeks. The rotation periods each lasted for thirty seconds, with interpolated rest periods, also of thirty seconds' duration. The mesial body plane was selected as the plane of rotation in order to stimulate predominately, if not exclusively, the vestibular receptors most intimately responsible for the particular equilibratory responses involved in perching. Plate 2 shows the device in which the birds were subjected (five at a time) to the repeated rotation. It will be noted that not only was the body of each bird immobilized, by being wrapped with a strip of cloth and then secured to the holder, but that each bird's head was also held relatively stationary by means of rubber bands attached to wire hooks which, in turn, were securely fastened to the bird's hood. This latter provision was necessary in order to prevent the birds from turning their heads during rotation in such a manner as to bring, from time to time, all of the vestibular receptors into the plane of rotation, which would have needlessly complicated the experiment.

*The subjects were usually quite "co-operative" during both the rest and balancing periods. If a bird flew or jumped off the perch during a balancing period, the score was simply discarded and the trial repeated.

At the end of two weeks of repeated rotation, during which time each bird had been subjected to 2,800 periods of rotation (84,000 revolutions in all), the ten birds were again tested on the perch in exactly the same manner as employed on the four successive evenings preceding the repeated rotation. It seemed quite probable from the data thus obtained that the repeated rotation of the birds had not affected their equilibrium adversely; in fact, their perching performance subsequent to the rotation was definitely superior—due, no doubt, to their previous practice—to their performance prior to the rotation. However, in order to determine whether the performance on the second perching series

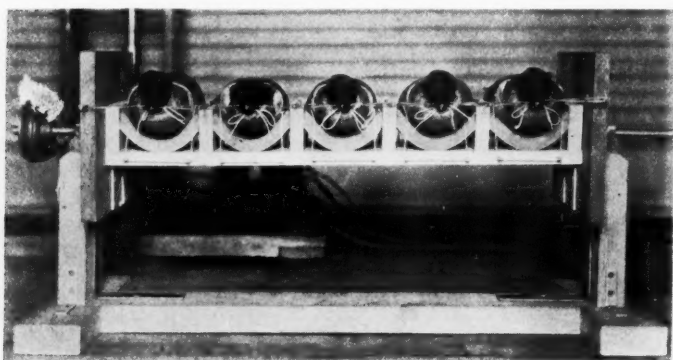


Plate 2.

might not have been still better than on the original series had it not been for the intervening rotation, i. e., in order to show that there had definitely been no impairment of equilibratory ability as a result of the repeated rotation, it was necessary to have comparable data from a group of "control" subjects. A second group of ten birds were therefore tested on the perch on four successive evenings in the manner previously indicated; and after a period of two weeks, during which time they were left unmolested in their loft, they were retested. The amount of improvement shown by the "controls" between the first and second tests was not detectably different from the improvement displayed by the "experimental" subjects, it being thereby indicated that the

repeated rotation to which the latter group of birds had been subjected had in no way disturbed their static equilibrium, as revealed by their perching ability. However, in order to be doubly certain that this finding was valid, a second experimental group of ten birds and a second control group of the same number were subjected to exactly the same procedures as had previously been employed with the original experimental and original control groups. But again there was no significant difference between the data secured from the two groups.

It is virtually impossible to obtain a satisfactory postrotational nystagmus from pigeons by means of rotation in the plane used in the present experiment; for if the head is left free during rotation, the bird usually moves it about in such a manner as to cause all of the vestibular receptors to be stimulated, with the result that the postrotational nystagmus is rotary or horizontal almost as often as it is vertical; and if the head is made stationary during rotation, it cannot be released soon enough after rotation has ended to permit a normal response. For these reasons no attempt was made in the present investigation to determine the amount of nystagmus reduction produced by the repeated rotation of the two experimental groups. Earlier observations³² have indicated, however, that a program of repeated rotation in the horizontal plane, comparable to the program of repeated rotation in the mesial plane described above, ordinarily produces a nystagmus reduction of about 50 per cent. It is assumed, therefore, that the birds used in the present study would probably have shown approximately the same amount of reduction had any practical means been available for obtaining a satisfactory response to rotation in the mesial plane; and it is further assumed that the absence of any detectable impairment of equilibrium in these subjects demonstrates that only the reflexes comprising vestibular nystagmus are weakened by repeated bodily rotation and that the remaining vestibular reflexes, i. e., those involved in the maintenance of static equilibrium, are probably entirely unaffected.

VI.

Quite aside from the difference in the way in which the nystagmic and the equilibratory reflexes are affected by repeated bodily

rotation, there are two other significant distinctions: (1) whereas vestibular nystagmus commonly persists for a very considerable time after the cessation of its original stimulus, the equilibratory reflexes disappear almost immediately after the cessation of the stimulus which has elicited them; and (2) whereas vestibular nystagmus is a rhythmical, clonic type of response, the vestibular responses involved in static equilibrium are more or less continuously sustained or tonic. The neuro-anatomic basis for these differences are not far to seek.

So far as is known at the present time, all neural fibers communicating with the vestibular receptors enter one or more of the various vestibular nuclei in the floor of the fourth ventricle.²³ From these nuclei three tracts are known to emerge: the tractus vestibulocerebellaris, the medial longitudinal bundle and the vestibulospinal tract.²⁷ Since all known vestibular reflexes are present after extirpation of the cerebellum,⁶ the first of the pathways just mentioned may be disregarded for present purposes. The fibers comprising the medial longitudinal bundle, on the other hand, are known to be responsible for the reflexes involved in nystagmus; and the fibers of the vestibulospinal tract are likewise generally believed to be responsible for the responses of the limbs and trunk involved in the maintenance of static equilibrium.

It was formerly supposed that the persistence of nystagmus after the cessation of the actual objective stimulus was due to some sort of continued disturbance (flow of endolymph, displacement of the cupula, etc.) within the vestibular receptors; but the more modern view is that this persistence of nystagmus is dependent upon the action of some mechanism in the central nervous system. Lorente de Nó^{22 23 24} has recently advanced good evidence for believing that this mechanism is located in the region of the primary vestibular nuclei, and that the "after-discharges" produced by it pass exclusively, or at least predominately, into the pathways involved in the nystagmic responses and influence but slightly, if at all, the equilibratory reflexes mediated by the vestibulospinal pathways.

The rhythmical feature of nystagmus is introduced, according to Lorente de Nó, by a second neural mechanism lying, however, outside the primary vestibular nuclei, presumably in the reticular

substance. It is this mechanism, says this writer, which accounts for the fact that of "the whole reaction to rotation (eye, head, body and limb reflexes) the nystagmus is the only reflex of rhythmic character."²⁴

Since the rhythmical pattern of postrotational vestibular nystagmus is not noticeably altered by the repeated elicitation of this response, it is to be assumed that the mechanism in the reticular substance, or whatever other mechanism it may be which is responsible for the rhythmical character of nystagmus,* is probably not significantly affected under these circumstances. On the other hand, since the duration of nystagmus is profoundly modified by repetition, it seems likely that the underlying neurologic change responsible for this modification occurs in the after-discharge mechanism located (by Lorente de Nó) in the region of the primary vestibular nuclei.

Lorente de Nó²² has demonstrated, on theoretical grounds, that if the excitation threshold or the refractory phase of certain of the neurons comprising this after-discharge mechanism becomes altered, there will be a change in the duration of the nystagmus produced by a peripheral stimulus of given duration and intensity. It is not entirely unreasonable to suppose that some such (more or less enduring) change may be produced by the abnormal stimulation resulting from repeated bodily rotation and that this change is responsible for the reduction in the duration of nystagmus commonly observed under such conditions. This, of course, is only a tentative and highly conjectural hypothesis; but it would seem to fit the facts better and to be more specific and tangible than any other theory known to the writer (cf. Mowrer³²).

VII. SUMMARY.

Previous investigations have convincingly demonstrated that the vestibular nystagmus occurring after bodily rotation may be substantially reduced—sometimes virtually abolished—by means of repeated elicitation. Experimental results are cited which indicate, moreover, that this reduction of nystagmus is not accompanied by, nor dependent upon, any demonstrable change in or

*Cf. Lorente de Nó.²⁵

injury to the vestibular receptors. It is emphasized, therefore, that the absence or unusual brevity of this response cannot be regarded as an unequivocal proof of vestibular pathology. Since original experimentation here reported has shown that the vestibular reflexes involved in the maintenance of static equilibrium are not detectably impaired by repeated bodily rotation, it seems probable that the effects of repeated rotation are limited to a reduction in the duration of nystagmus (and in the vividness of the subjective phenomena which have been shown to be dependent upon nystagmus). It is suggested, finally, that the shortening of postrotational nystagmus produced by repeated elicitation may be dependent upon a more or less enduring change produced in the stimulation threshold or in the refractory phase of certain of the neurons comprising the so-called after-discharge mechanism upon which the persistence of vestibular nystagmus after the cessation of actual, objective stimulation is now thought to be dependent.

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XXVIII.

THE EFFECT OF SEVERE ILLNESS UPON THE HEARING.*

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For the past five years I have been testing the hearing of seriously ill persons, primarily with the object of subsequently correlating hearing losses with the lesions found at autopsy. Although the great majority of these patients recover sufficiently to leave the hospital, some subsequently return, have a second test, and a few come to autopsy. Over a thousand audiograms have been made and 500 temporal bones obtained.

Autopsy evidence presents a picture often difficult to correlate with the clinical symptoms, sometimes because of terminal inflammations which were not present at the time the tests were made. Clinical evidence is the only evidence which gives an accurate picture of function. Small variations in hearing function may now be measured by instruments of precision.

It would seem logical to believe that severe illness should cause some disturbance in function in all sense organs, and particularly in so fine and intricate an apparatus as the auditory. To determine what effect, if any, a severe illness has upon the hearing I have grouped audiograms according to the diseases suffered. The intention was to give in this paper a report upon all the illnesses encountered, but on examining the data I found that there was a superabundance of material. In fact, so much that it is advisable to discuss but one disease group at this time.

I shall limit my report to the findings in the seriously ill with arteriosclerosis. To better visualize the data the patients have

*Presented before the annual meeting of the American Laryngological, Rhinological and Otolological Society, at Charleston, S. C., April 4, 1934.

This work was made possible by the co-operation of the departments of Medicine, Otolaryngology and Pathology of the Presbyterian Hospital, Columbia University. The audiometer was supplied by the American Federation of Organizations for the Hard of Hearing. The tests were made by Miss Marie A. Pless, a trained nurse and most competent technician, from the New York League for the Hard of Hearing.

been divided into five groups, representing the five decades from 30 to 80 years, inclusive. Air conduction and bone conduction tests were made with the 2A Western Electric audiometer in the Presbyterian Hospital. Hospital wards are not always quiet places, but the number of normals obtained make it apparent that the ever-present noises interfered but seldom with accuracy. It is conservative to consider, under the conditions, that a 10 S. U. loss in hearing is within low normal and to count all such losses and less as indicating no loss of hearing. This simplifies the picture somewhat and makes our figures very conservative.

Drowsiness, apprehension, lack of coordination, extreme weakness, exhaustion and undue ward noises have been noted in tabulating each case, and account for some of the otherwise seemingly strange figures. The usual ward noises do not affect the accuracy of the tests in those with considerable deafness.

Twenty fracture cases were charted, to act as controls, but as some had arteriosclerosis and others definite histories of ear disease, their usefulness as controls is dubious, and moreover the number is too small to allow division into age groups. As better controls I will show the Bunch and Raiford¹ averages for all hospital patients in four decades from 30 to 70 years, inclusive, and at the same frequencies as my own, namely: 256, 1024, 4096 and 8192 by air conduction. Bunch's² report of the average hearing in 137 cases (thirty less than mine) of arteriosclerosis shows similar but slightly greater losses than my own. He did not include the eighth decade or bone conduction tests. He did not exclude the worse ears. I will also show the proportional losses by bone conduction at 256, 1024 and 4096. This has not heretofore been done. Some consider the audiometer bone conduction receiver unreliable, but this has not been my experience. I find that bone conduction in deafened ears is often more reliable than air conduction, notably with obstructive lesions. Rarely was it found less than air conduction. This fact alone proves its value as a quantitative measure of inner ear, nerve and central functioning.

For air conduction I have chosen 256 DV to represent the low tones because it is the lowest tone for which feeling is not apt to be mistaken for hearing and because whenever the hearing is down for one of the low tones it is down for all the lower tones.

I have chosen 1024 DV to represent the middle tones because it is near this frequency that we often find a peak in our audiometric curves. I have chosen 4096 because it is about midway between 1024 and 8192, and because marked deficiencies in the hearing often occur in this area. I have chosen 8192 because it is the highest frequency of the 2A audiometer and if there are losses for higher tones testing with this frequency will usually disclose this fact.

For bone conduction I have omitted 8196 because it is of questionable value. Tests of this frequency, however, were made in all cases.

There were 167 cases of arteriosclerosis with various complications, mainly cardiac and arterial insufficiencies, essential hypertrophies, dilatations, decompensations, nephritis, aneurisms, secondary anemias, hyper- and hypo-tensions, coronary thromboses and various other heart lesions; cerebral, pulmonary, gastric and hepatic diseases; also rheumatoid arthritis, thyroid diseases, diabetes, syphilis and tuberculosis. All of these will be considered at some future time under their own disease groups, but it is manifest that they too might have a varying effect upon hearing acuity, depending upon their severity. Tabulation of these cases covers fifteen closely written pages, and not enough would be accomplished by publishing the figures to warrant the space required. Summaries will give a better general understanding of the findings. The summaries were obtained from the losses in hearing by air conduction sound, and from the losses in hearing by bone conducted sounds.

Many methods of tabulating were used, but the following I believe will suffice for a discussion of the subject.

The first table is a summary of the hearing losses by air and by bone conduction found in the 167 cases of arteriosclerosis arranged according to the five decades of life between the ages of 30 and 80, inclusive. There were not a sufficient number of audiograms taken in the first and second decades of life to warrant study at this time. Arteriosclerosis is infrequent in the young. On the left of the chart is placed the number of cases in each group.

In each instance the hearing of the better of the two ears has been tabulated, because the histories show that the worse ears have

TABLE I.

SUMMARY OF HEARING LOSSES (IN S. U.) BY AIR AND BY BONE CONDUCTION
IN 167 CASES OF ARTERIOSCLEROSIS.

BETTER EARS		256		1024		4098		8192
No. of Cases	Age Groups	AC	BC	AC	BC	AC	BC	AC
20	30-39	11.5	1.25	13.8	5.75	17.	10.25	13.5
20	40-49	16.51	1.68	13.78	6.	17.5	12.	19.03
58	50-59	18.50	3.1	18.62	6.9	27.03	15.57	26.54
48	60-69	18.95	3.75	20.94	10.	33.62	22.08	30.09
21	70-80	25.47	4.53	25.71	14.3	39.09	31.43	47.
Controls								
20	30-73	18.5	2.5	13.5	3.	18.25	11.25	18.75

Average losses in the worse ears were often little below those in the better ears. The form of the audiometric curves of the better and worse ears was almost identical in 90 per cent of the cases. Great variations could usually be accounted for by past histories of suppurations.

often suffered from deafness due to otitis media in the past. Our immediate purpose is to concentrate not on middle ear pathology but upon the influence of the general disease. The better ears therefore give a truer picture of the effect of such diseases than do the worse ears. However, the hearing in the worse ears in the great majority of cases was little below the hearing in the better ears (in 90 per cent of cases not over 10 S. U.), and the form of the audiometric curves of the better and worse ears was almost identical in 90 per cent of the cases. Therefore in 90 per cent the causes operating to produce the deafness in the two ears would appear to have been similar. In the few instances where great variations occurred between the patterns (the form of the graphs) past histories of suppuration could usually be elicited.

In 30 per cent of the controls there was a history of deafness from old middle ear suppurations, and in 20 per cent a long standing nerve deafness. Some of these cases were down 40 to 65 S. U. in the lower and middle frequencies, and some were beyond the intensity range of the audiometer at 4096 and 8192. Ten per cent of the controls had arteriosclerosis. These conditions made the

control averages low and of little value for comparison. It is difficult to obtain a fair average with so many confusing factors.

In the 50-59 group 25 per cent had a definite history of past suppurations in at least one ear, or long standing deafness, and several of the better and worse ears were markedly down in consequence. Many were extremely ill and under the effect of sedatives and uncooperative. In the 60-69 group 14 per cent had a history of past suppurations and deafness. The fact should not be ignored that with past histories of suppuration in one ear there has often been a suppuration in the other ear which was not diagnosed, and which healed leaving little evidence of its presence except maybe deafness. Of course, past inflammations, though not recognized, may make an ear more susceptible to deafness from general diseases. The hearing is lowered and subsequent disease lowers it further.

The figures under each frequency (by air and by bone conduction) represent the average of the losses of all the better ears in each age group, as indicated under "Age Group." By air conduction there were no losses at 4096 DV below the limit of the audiometer (85 S. U.); at 8192 DV, losses that were below the limit of the audiometer were averaged at 85 S. U. (Only one in the 40's and 60's, six in the 50's and five in the 70's.) In only two instances (both at 4096) was bone conduction down beyond the range of the audiometer (over 50 S. U.). They were averaged at 65 S. U. This was the highest frequency recorded for bone conduction measurements. These would seem to be conservative figures.

I tabulated also the number of cases in each group having a 15 S. U. loss, 20 S. U. loss, 25 S. U. loss, and so forth down to 85 S. U. loss, and whereas this is interesting, it required six pages of tabulation to show the data, and so I will give you only the percentages of normal ears (those with 10 or less S. U. losses) in the five groups, and under four frequencies by air conduction and under three frequencies by bone conduction.

Fig. 1 shows graphically the data given in Table I. It is self explanatory. The solid lines represent my figures, the dotted lines those of Bunch and Raiford.

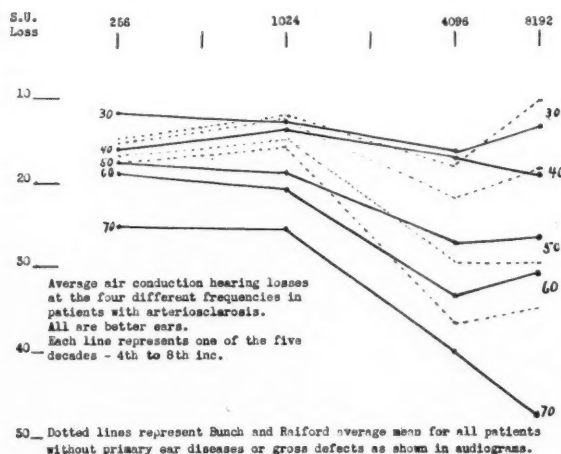
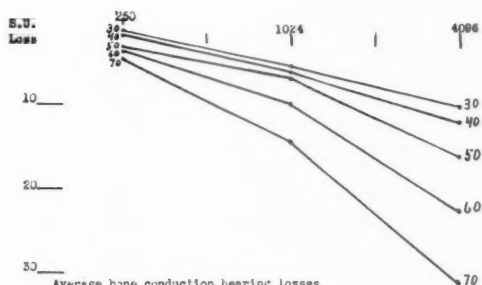


Fig. 1a. Average air conduction hearing losses at the four different frequencies in patients with arteriosclerosis. All are better ears. Each line represents one of the five decades—4th to 8th, inc. Dotted lines represent Bunch and Raiford average mean for all patients without primary ear diseases or gross defects as shown in audiograms.

The following should be noted. (Remember we are dealing with average losses):

1. The small but progressive loss of hearing with age (up to 70 years) at 256 DV.
2. The still small but progressive loss of hearing with age (up to 70 years) at 1024 DV.
3. The larger and more progressive loss of hearing with age (up to 70 years) at 4096 DV.
4. The large and generally more progressive loss of hearing with age (up to 70 years) at 8192 DV.
5. After the age of 50 the larger losses in the higher frequencies at 4096 and 8192.
6. After the age of 70 the marked losses at 256 and 1024 but much greater losses at 4096 and 8192 DV.

Comparing these graphs with those of Bunch and Raiford for patients with all kinds of diseases, it appears that in the lower tones



Average bone conduction hearing losses at the three different frequencies in patients with arteriosclerosis. All are better ears. Each line represents one of the five decades - 4th to 8th inc.

Compare the bone conduction losses at each frequency with the losses by A.C. Bone conduction measurements show the loss of nervous apparatus efficiency.

Fig. 1b. Average bone conduction hearing losses at the three different frequencies in patients with arteriosclerosis. All are better ears. Each line represents one of the five decades—4th to 8th, inc. Compare the bone conduction losses at each frequency with the losses by A. C. Bone conduction measurements show the loss of nervous apparatus efficiency.

(256 DV) there is little difference between the two sets of data. In the upper tones (4096 DV and 8192 DV) (except in the 30-39 and 40-49 decades, at 8192), the Bunch and Raiford losses are somewhat greater than the arteriosclerosis losses. These authors give no figures for the 70-79 decade. None of the discrepancies are over 5 S. U., and may be due to differences in extraneous noises, although as a rule hearing for high tones is less affected by noise than hearing for low tones. The main reason for the variations is that the Bunch and Raiford figures included both the better and the worse ears. Mine only the better ears.

It is logical to believe that in both sets of data, the losses for high tones are generally coincident with advancing age. None of the cases acquired deafness while in the hospital. Some stated their hearing was less acute since severe illness supervened. Many definitely hard of hearing patients had acquired deafness so slowly that they did not realize any hearing difficulty.

Age is regularly accompanied by arteriosclerosis (usually cardiovascular disease), and hence arteriosclerosis may commonly be the determining factor in the hearing loss of old age. It may be definitely stated that the lesions causing deafness in arteriosclerotics are mainly ganglion, nerve or cortical lesions, or all of these. This belief is made probable by the fact that with advancing years arteriosclerotics on the average show a definite loss of hearing at the middle and higher frequencies by bone conduction in an increasing ratio with age. At the low frequencies bone conduction is often down surprisingly little, which suggests the probability that some of the loss in hearing acuity has been often caused by middle ear lesions. Few ears are seen at autopsy without some middle ear lesions, and these lesions are accentuated in old age by increasing fibrous connective tissue, calcium deposits and diminished elasticity. On the other hand, it is seen that the aged may escape these effects, because many have normal hearing ears. In other words, age alone is not the cause of hearing losses by air conduction or by bone conduction.

The average A. C. losses are about the same for the lower and middle frequencies (256 DV and 1024 DV), but are more marked for the higher tones. Except for those over 70 years of age, there is little difference between the average losses at 4096 and 8192 by air conduction, but the 4096 measurements are down further than the 1024 measurements by both air conduction and bone conduction.

The statement is often seen that bone conduction is lost in old age. It may be lowered and so may air conduction be lowered, but neither are lowered or lost merely because of age. Otherwise how account for the old people with normal hearing by air and by bone conduction? Of course, normal hearing is not the rule in old age—far from it.

Table II shows for comparison the percentage of better ears with normal or near normal hearing by air conduction, and with normal or near normal by bone conduction, at the different frequencies in patients with arteriosclerosis in the five decades between 30 and 80 years, inclusive. Fig. 2 shows this graphically. The percentage of ears with normal hearing for the different

TABLE II.

THE PERCENTAGE OF CASES WITH NORMAL HEARING AT THE DIFFERENT FREQUENCIES BY AIR CONDUCTION AND BY BONE CONDUCTION.

BETTER EAR:

Age Groups	256		1024		4098		8192
	AC	BC	AC	BC	AC	BC	AC
30-39	75%	100%	50%	85%	35%	75%	55%
40-49	43%	100%	55%	90%	49%	79%	70%
50-59	15%	100%	31%	90%	17%	45%	33%
60-69	29%	92%	29%	67%	17%	27%	21%
70-80	6%	100%	5%	57%	5%	10%	10%

The percentages for air conduction are shown on the left, the percentages for bone conduction on the right. The irregularities in the air conduction averages are due largely to obstructive lesions. The irregularities in the bone conduction averages are very small.

frequencies is surprisingly large. It appears that with advancing years, hearing acuity usually diminishes in progressive ratios, especially at the higher frequencies, and for the higher decades, but in many instances this is not so, at least up to 80 years of age. Even in the 70's, the figures show that 5 per cent of arteriosclerotics have normal hearing for air conduction at 256, 1024, 4096, and unexpectedly 10 per cent have normal hearing at 8192.

You will notice in the sixth decade that the percentage of normal ears is very low for air conduction, 15, 32, 17 and 33 per cent at the four frequencies respectively, but that for bone conduction these same ears averaged normal in 100, 90 and 45 per cent under the frequencies given.

Bone conduction percentages give a truer picture of the nature of the deafness in arteriosclerosis than do the air conduction percentages.

To illustrate how varied functional responses may be accounted for in arteriosclerosis, I shall show sections from two cases with arteriosclerosis* in correlation with the hearing acuity in each instance. Arteriosclerosis is a patchy disease. If found in one

*These sections were prepared under the supervision of my son, Dr. Edmund P. Fowler, Jr.

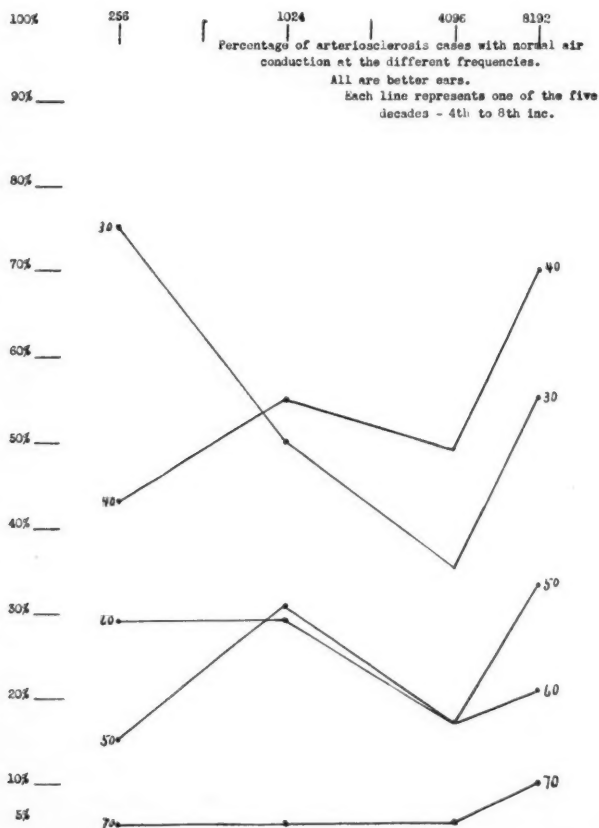


Fig. 2a. Percentage of arteriosclerosis cases with normal air conduction at the different frequencies. All are better ears. Each line represents one of the five decades—4th to 8th, inc.

place it need not be present in distant or even near by places. "Silver wire" arterioles in the fundus of the eye indicate blood vessel disease, but they are not necessarily pathognomonic of cerebral or kidney disease, medical books to the contrary notwithstanding. So that, even with general arteriosclerosis one cannot be certain of arteriosclerosis in the ear, but if there are progress-

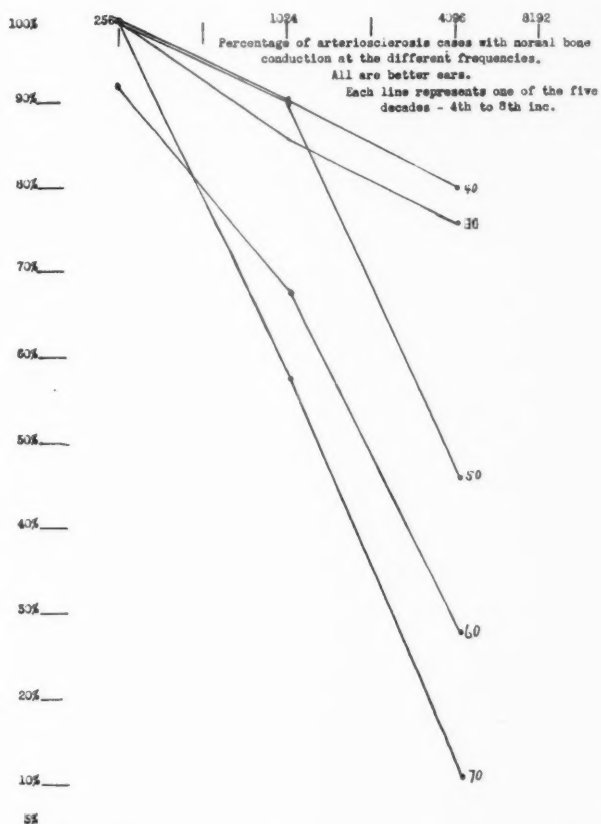


Fig. 2b. Percentage of arteriosclerosis cases with normal bone conduction at the different frequencies. All are better ears. Each line represents one of the five decades—4th to 8th, inc.

ive losses of hearing by air and by bone conduction and with frequency my studies would seem to indicate that such is the case, other causes being eliminated. Contrawise, the absence of progressive losses, and especially for the higher tones, would appear to exclude arteriosclerosis in the ear vessels as a cause of the deafness. For example, a patient, 71 years of age, who died of

a cerebral hemorrhage, had marked arteriosclerosis throughout his body, but the spiral ganglia in his modiolus appeared near normal. Clinically he heard a watch tick at 20 cm. (normal for this watch). Although occluded small vessels were apparent in nearly every other organ of his body, none could be found in the modiolus or internal meatus. The ganglia cells in some of the basal turns seemed to be decreased in number, but in no place in the sections was there any apparent decrease in the nerve fibrils running outwards in the spiral lamina to the organ of Corti.

Fig. 3 is an audiogram of the two ears of a woman, 45 years of age, who subsequently died of a cerebral accident. She had

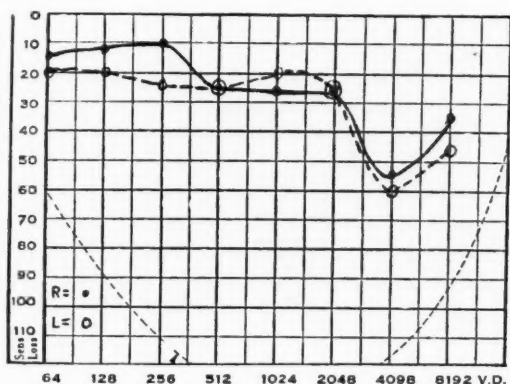


Fig. 3. Audiograms of the hearing in a 45 year old woman with general arteriosclerosis.

marked general arterial and arteriolar disease, both clinically and pathologically. Two months before she died she developed a severe high pitched tinnitus. She was sent to the general ear clinic, where an air conduction audiogram was done in a relatively noisy room. Unfortunately, no bone conduction readings were made. Because she had slightly dulled drums and moderate retraction, mostly on the right, a diagnosis of O. M. C. C. was made, and she was treated with inflations. Her terminal episode was quite sudden, and at autopsy thickened and occluded vessels were found in her brain, meninges, eye grounds, heart, lungs, kidney,

liver, spleen and elsewhere. In the temporal bones the most markedly occluded vessel was a vessel near the geniculate ganglion (Fig. 4), but of special interest is a vessel near the basal turn of the cochlea, which was also practically shut off by an intimal plaque. The ganglia cells of this turn at its lowest point are markedly decreased in number. The fibers from these ganglion cells to the organ of Corti are also greatly decreased in number. The ganglion cells in the higher turns are relatively normal. In

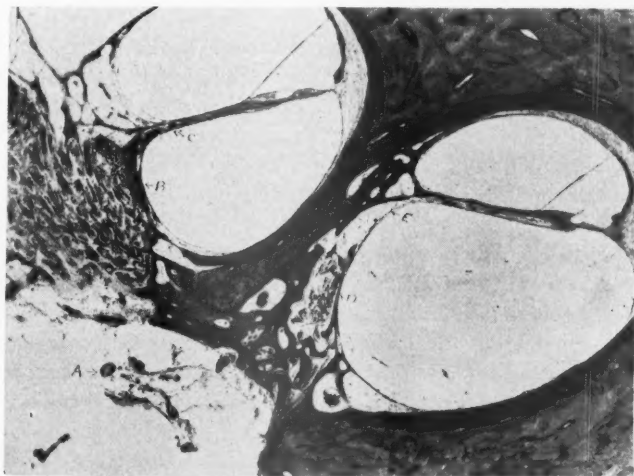


Fig. 4. Photomicrographs of the 45 year old woman showing occluded vessel near the basal turn of the cochlea. The ganglia cells at the lowest point and the nerve fibers to the organ of Corti are greatly decreased in number.

the hypertympanum is some scar tissue suggestive of previous inflammatory disease, but the stapes is free of adhesions. Bone conduction readings of this case would have made possible a more accurate diagnosis.

SUMMARY.

Audiometric tests by air and by bone conduction of patients seriously ill with arteriosclerosis show, in the great majority of cases, hearing losses increasing with frequency and with age.

Many very old people, even with severe arteriosclerosis, appear to have normal hearing because the vessels of the inner ear or higher centers are not diseased.

Identical or similar graphs were found for both ears in 90 per cent of the 167 pairs of ears examined, which made it appear that the etiology was similar for both.

Similar lesions in the inner ear or in the higher acoustic tracts and centers are the logical explanation for similar bilateral losses of hearing by air and by bone conduction, other factors being eliminated.

It would appear that in patients over 50 years of age, audiometric measurements showing losses of hearing, especially in the higher frequencies are suggestive of cardiovascular disease, especially arteriosclerosis, if other causes of nerve deafness can be eliminated.

Bone conduction measurements give a truer picture of the lesions causing deafness from cardiovascular diseases than do air conduction measurements, because they are measurements of the nerve apparatus functioning and show a more orderly ratio of progress at the different frequencies with advancing age.

By eliminating the confusing effects upon the hearing of conduction lesions, tests by bone conduction aid diagnosis, and call attention to general disease, often cardiovascular disease, as a possible factor, and often the most important factor in the etiology of the nerve deafness.

Autopsy findings were correlated to the clinical findings. They indicate that arteriolar sclerosis is found more often in the internal auditory meatus than in the modiolus, and that the essential lesion is a degeneration of the ganglion cells and their terminal fibers in the lower turns of the spiral lamina.

It would appear that audiometric measurements in arteriosclerosis with hearing losses could be used as an aid in determining the rate of progress of the cardio-vascular disease.

140 EAST 54TH STREET.

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XXIX.

NOTES ON THE DIAGNOSIS OF OTITIC MENINGITIS.*

SAMUEL J. KOPETZKY, M. D.,

NEW YORK.

The problems concerned with otitic meningitis are many. In this short paper, I desire to call attention to a means of diagnosing a meningeal infection of otitic origin in its very early stages. The desirability of this is obvious. In passing, it may be permitted to comment on factors concerned in this means of diagnosis.

According to most investigators the cerebrospinal fluid is a dialysate. The fluid filtrates from the capillaries of the choroid plexus, and from the capillaries of the perineural and perivascular spaces of the central nervous system. Eventually it reaches the venous blood channels, being absorbed into the longitudinal and lateral sinus of the skull. In its normal state the fluid is in osmotic equilibrium with the blood plasma, and its production and flow may be termed to be influenced toward an exaggerated production or a retardation by a relative dilution or concentration of the blood. (Weed.)

The cerebrospinal fluid carries on a dual function. It is concerned with metabolism of the brain cells, carrying away the effects of ketabolism; and its other function is that of equalizing and maintaining intracranial pressure.

Meningeal infection disturbs these normal functions, and as a result phenomena occur which can be recognized when studying the fluid. In the ordinary condition, the fluid transudes through the capillaries of the choroid plexus in the face of the intracranial pressure, and becomes again absorbed under the influence of the same pressure. The fluid follows the general rule laid down by Starling in his study of body fluids. Whether due to bacterial activity or not, it is as yet undetermined. But the first effect of

*Read before the Eastern Section of the American Laryngological, Rhinological and Otological Society, Rochester, New York, on January 5, 1934.

a meningeal infection is a great outpouring from capillary blood vessels of fluid. To some this is observed as a defense mechanism of the body, to cleanse itself of the invading pathogenic bacteria and their tissue reactions. As a result of the outpouring of cerebrospinal fluid there is a demonstrable increase in intracranial spinal fluid pressure. Exudates have not yet formed to any appreciable extent, and the connecting orifices between the various ventricles and the meshes in the pia are still open.

The mass effect generally of increased intracranial fluid pressure is compression of the intracranial blood supply. Both afferent and efferent vessels are subjected to this pressure. This produces lessened oxygenation of the parts concerned, namely, the brain tissue. The researches of Meyerhof and Warburg have shown that the result of lessened oxygen tension is an incomplete oxidation of carbohydrates so that the so-called anaerobic type of oxidation preponderates over the aerobic, and large quantities of lactic acid results. In the study of spinal fluids from meningitic cases, I reported, in 1912, my finding of a marked lactic acid increase. In a more recently published study (1933) I was able to corroborate the earlier observation. In the very early stages of meningitis there is always present in the cerebrospinal fluid an increase in its lactic acid content. Lactic acid is also present in increased amounts in blood plasma, especially during fever. Since the early stage of meningitis with which I am dealing is always accompanied by fever, it becomes necessary to estimate the amount of lactic acid present in the patient's blood plasma at the same time that the spinal fluid estimation is made. The lactic acid has been found to be very much higher in the cerebrospinal fluid than in the blood plasma, and it is possible to establish a ratio between the two findings. The lactic acid content of the meningitic spinal fluid is four times that of the lactic acid content of the blood plasma.

There are several interesting and pertinent phenomena that result from the presence of this acid in increased amounts in the cerebrospinal fluid. These results can be comprehended as tissue reactions in the brain tissue cells, and in a further chemical interaction in the chemical elements comprising the spinal fluid.

The second stage in the development of the meningitic lesion deals with intrinsic cell changes in the brain tissue, the cells of the choroid plexus, the perineural and perivascular spaces. Cell function becomes hindered, and as a result the effects of cell metabolism are found in the fluid in the form of cholin in greater amounts than normally. I assume that the detail of the lesion, at the stage in question, is an edema of the structures concerned. My assumption is based on the known fact that the presence of the lactic acid in increased amounts must result in a changed iso-electric reaction of the spinal fluids and the cells bathed by it. Attention here may be called to the theory of Fisher, who places, in his studies of edema, its causative factor in the water-binding property of tissue colloids. When small amounts of acids are added to iso-electric gelatin, its swelling power is enhanced. Fisher contends that the cause of edema is to be found in the accumulation of acid products in the tissues. I realize that Fisher's theory has been critically questioned, and is held as not proven, but nevertheless, as far as the stage of meningitis is concerned with which I am dealing here, his theory seems to find a degree of substantiation. We have brain tissue colloids bathed in a fluid whose reactions are tending to swing toward the direction of "lessened alkalinity," and as a result we see edema and an interference with cell function.

The presence of the strong lactic acid results in a decrease in the alkalin reserve, or since in the modern nomenclature the actual expression of acidity is termed, in common usage, the minus logarithm of the actual concentration of the hydrogen ion which is present, we find a lowered ph. Our finding in meningitic fluids is 6.9 and 7.0 instead of the normal 7.5. When it is remembered that a change of 1 in ph. is equivalent to ten times that amount in actual change in concentration of hydrogen ion, and that a lowering of the ph. of 0.5 in blood cannot sustain life, the actual significance and fundamental character of the lowering of the ph. of even 0.5 becomes apparent. The chemical phenomena of increased lactic acid in the spinal fluid has further consequences. The lactic acid being a strong acid drives off CO_2 from the carbonates, and hence in meningitis we should expect to find, and

there is in fact, found in addition to the very considerable lowered ph., a decreased bicarbonate content.

In a study of meningitic fluids published in collaboration with Dr. E. H. Fishberg, attention was called to the effects of the lactic acid increase upon the equilibrium maintained between blood plasma and cerebrospinal fluid, in accord to Donan's law, and to the measure of the distribution of the ionic constituents between

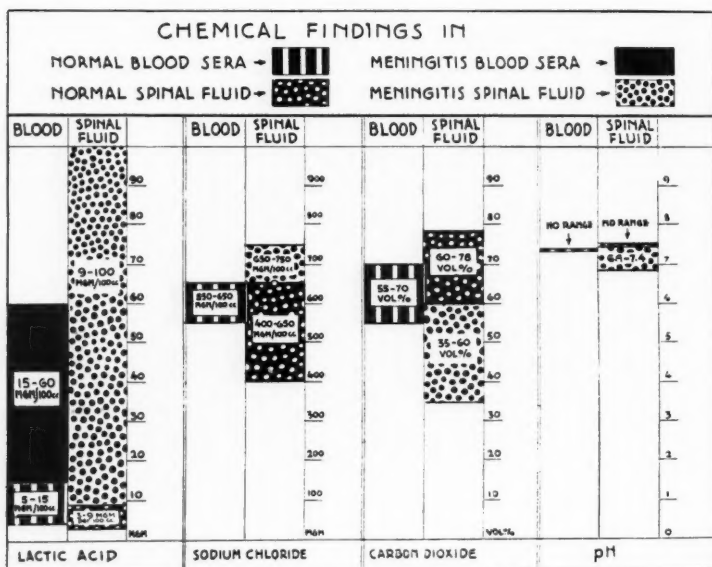


Chart I.

plasma and spinal fluid. To summarize, there was found in all cases of meningitis, a significant lowering of the spinal fluid chloride and a decrease in the gradient between spinal fluid chloride and blood plasma chloride. This has distinct diagnostic value.

I am attempting to fix attention to the diagnosis of meningitis in its very earliest stages of development. In the stages long before bacterial content, cytology and the accompanying clinical

picture of a developed meningitis makes biochemical diagnosis unnecessary and useless.

Success in therapy will eventually come from so early a diagnosis, and the institution of remedial measures at a time so early in the evolution of the lesion that resolution may set in before plastic exudates and cell destruction so damages vital centers that life must cease. The bedside symptomatology is not proportionate to the severity of the lesion. The latter can only be surmised from a careful study of the cerebrospinal fluid in all its findings—pressure, cytology, chemistry and bacteriology. Each factor tells

	BLOOD PLASMA		SPINAL FLUID	
	NORMAL	MENINGITIS	NORMAL	MENINGITIS
CARBON DIOXIDE (VOL.%)	55-75	55-75	65-80	35-55
CHLORIDE (MG/100 CC)	550-650	550-650	650-750	450-550
LACTIC ACID (MG/100 CC)	5-10	15-50	5-7	15-200
pH	7.43	7.3-7.45	7.5	6.9-7.3
			NORMAL	MENINGITIS
SPINAL FLUID/BLOOD PLASMA GRADIENT				
FOR CHLORIDE			+75	-20 to -50
" CARBON DIOXIDE			+1.5 to +5.0	-5 to -20
" pH			+0.1	-0.15 to -0.5
SPINAL FLUID/BLOOD PLASMA RATIO				
FOR LACTIC ACID			0.6 OR LESS	1 to 4

Chart II.

part of the story; the clinical picture is but a summation of many elements. Clinical observations have shown that meningitic cases, where a free flow of cerebrospinal fluid is obtainable, give the best therapeutic results. Where the flow is hindered by exudates, mechanical obstructions in the communicating pathways between the ventricles, where the fluid thickens due to concentration and large cell content, good therapeutic results are rarely obtained. It is at the very commencement of the meningeal reactions where the chemistry of the cerebrospinal fluid will have its most important use. It is axiomatic in the treatment and management of

intracranial lesions that frequent observation and study of the patient enable the observer to estimate the probabilities and eventualities of the meningeal reaction. The early examination of the cerebrospinal fluid is part of such early study.

In Chart I is a graphic summation of the findings in normal blood and in spinal fluid contrasted with the same elements found in an average case of meningitic fluid, and plasma from the same

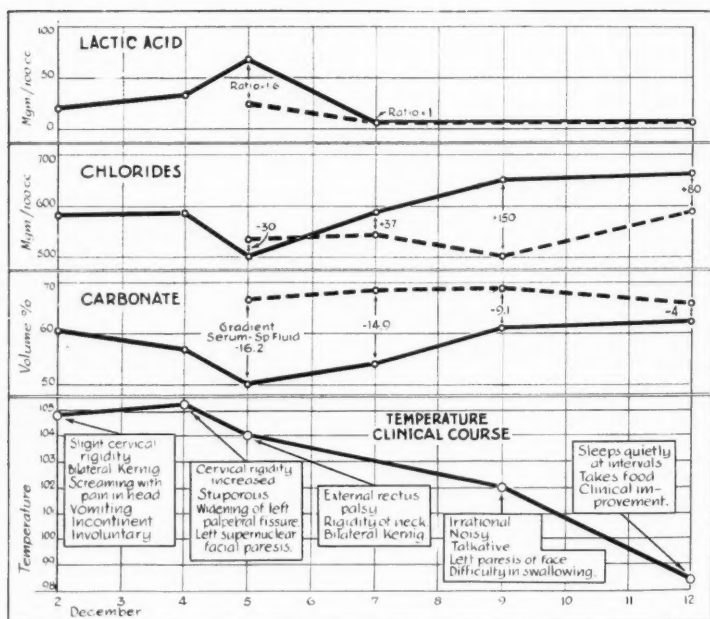


Chart III.

meningitic patient. This graphic estimation is shown in numbers on Chart II in greater detail.

Chart III represents the findings of carbonates, chlorides and lactic acid from a patient with meningeal involvement, whose clinical picture was significant of a meningitis and a brain abscess. The chemical findings in the fluid gave early evidence of a resolution of the lesion before the clinical picture cleared. The

chemical findings are charted in contrast to the temperature chart and clinical notes. The lactic acid ratio returned to normal December 7, 1933, the gradients of the chlorides and the carbonates tended toward the normal, while yet the clinical picture was clouded. The eventual clinical course followed the indices in the spinal fluid, blood plasma estimation and, without any additional surgery to the mastoidectomy the patient is on the road towards recovery.

Studies of progressions and regressions of meningeal lesions as estimated from the chemical reactions of the fluid are in progress and will be reported.

51 WEST 73RD ST.

XXX.

OTOSCLEROSIS IN ULTRAVIOLET LIGHT.*

E. P. FOWLER, JR., M. D.,

NEW YORK.

The structure of otosclerotic foci varies according to the age and the activity of the particular focus in question. The most characteristic bone is bone with an irregular fiber structure called "reticular bone," or "short-fiber web bone" (*geflechtartiger knochen*). Secondarily, Haversian systems may form, but most of the bone remains of the short-fiber web type and the lamellar structure in any Haversian system which does form is often quite irregular (Fig. 4). All this has been observed by using fiber stains or the polarizing microscope by Otto Mayer,¹ Max Meyer,² Weber³ and others. Ultraviolet photomicroscopy is a refinement of their methods and brings out the fact that the large fat fibers described with silver stains are in reality bundles of fibrils. It, furthermore, allows more accurate reproduction of structure, which has heretofore only been shown in drawings.

As described in a previous communication,⁴ the illumination used for ultraviolet photomicroscopy is a magnesium arc whose light is broken up into a spectrum by quartz prisms. There appears a very sharp bright line characteristic of magnesium and of cadmium at a wave length of 280 mm. in the ultraviolet. This bright line is reflected upwards into the microscope and is the sole source of illumination. Since most ordinary glass stops wave lengths shorter than 350 mm., it is necessary to mount the specimens on quartz slides and cover slips and to have quartz lenses in the microscope as well as quartz in the apparatus for breaking the light into a spectrum.

*Presented before the sixty-seventh annual meeting of the American Otological Society, Atlantic City, N. J., April 6, 1934.

From the Department of Pathology, Columbia University, under various grants from the Research Council of the American Otological Society, the New York League for the Hard of Hearing, and the Department of Otolaryngology, Columbia University.

The quartz optics for 280 mm. band of an arc were perfected by Kohler in 1904.⁵ He calls the lenses monochromats because, of course, they need not be corrected for the many wave lengths of polychromatic white light. The technic of using the ultraviolet microscope is only slightly more tedious than the taking of ordinary photomicrographs. The fields are smaller than can be obtained with modern glass optics, and one can not so well follow the structure of an object in the axis of the microscope by focusing up and down as with direct vision in white light. These limitations have, perhaps, prevented a more universal use of the machine, but it has certain very distinct advantages entirely its own, namely, it has more than double the resolving power of the ordinary microscope and through selective absorption it permits the study of tissues before they are stained. Further, it focuses sharply enough for photographs to be taken at various levels in thick sections. It is therefore an ideal method for the study of fiber structure in bone. It is apparent that if two fibrils are so small and so close together that they appear as one fiber in white light which has a mixture of all the wave lengths from 600 to 400 mm., it might be possible to make them more distinct by using a light, such as a monochromatic light of 280 mm., that vibrates at a smaller amplitude and has no interference from other vibrations.*

Now, the adult temporal bone has a particularly bazar structure to those who have studied only the more common preparations of rib, vertebrae, femur and calvarium. The endochondral capsule takes up the basophilic stains quite heavily and contains many cartilage-like islands which gives it an even more basophilic appearance under low powers. With fiber stains, the polarizing and the ultraviolet microscope, it is found to be made up of parallel fiber bone which runs in skein-like fashion about these basophilic islands and about islands of short fiber web bone. There are none of the familiar Haversian systems except in very old people and in diseased bones. Against the blue or violet of the normal cap-

*I am indebted to Prof. Charles Boedecker of the Department of Dental Histology, Columbia University, for the use of his ultraviolet microscope. It was only through the cooperation of Prof. Boedecker and his assistants that this work was made possible.

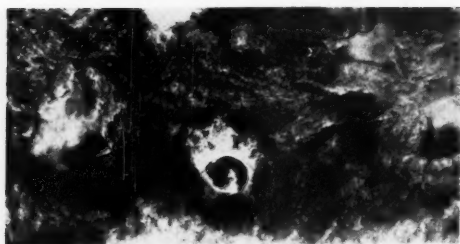


Fig. 1. Ultraviolet photomicrograph of short fiber web bone (geflechtartiger Knochen) from the femur of a 7-months embryo, unstained. (Glycerin immersion 1.7 mm. Obj. 5x ocular x1400 actual size.)

sule in hematoxylin-eosin sections, diseases of the bone stand out very sharply. Nowhere is it easier to pick up Paget's disease, nowhere is the osteoporosis and the new growth of bone of senility more apparent. All this has led certain observers to think that the temporal bone, and especially the endochondrial capsule, has no counterpart, and because otosclerosis is a disease of this particular bone they think that it too can have no counterpart. The ultraviolet microscope confirms the observations and deductions of those who have worked on the fiber structure of the temporal bone, but it shows that given areas in other bones may have an identical structure, both normally and pathologically.

For example, beneath the periosteum of a growing long bone the first bone laid down is often a parallel fiber bone. The short fiber web bone and the basophilic islands are to be seen in the osteoblastic areas in any young growing bone at the epiphyseal lines. Fig. 1 shows a high power (x1400) of the short fiber web bone of a spicule from the femur of a 7 months embryo. Fig. 2 is new bone in the petrous tip of a case of petrositis. It would be impossible to differentiate this from the short fiber web bone in an actively growing otosclerotic focus (cf. Fig. 3 and Fig. 4, A). With hematoxylin-eosin preparations the fiber structure of bone is suggested by the cells. If the lacunar spaces are round, irregularly arranged and the canaliculi run in all directions, the bone is probably of the short fiber primitive type. The similarity of otosclerotic foci to embryonal bone and new bone of inflammatory origin, etc., is therefore also apparent in Hand E sections.

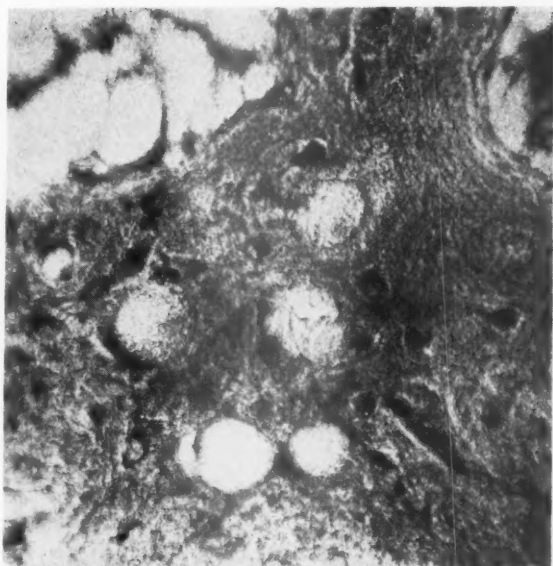


Fig. 2. Ultraviolet photomicrograph of short fiber web bone from petrous tip of a case of petrositis. 6 mm. Obj. 5x ocular, x250.

For many years an argument has been waged over whether otosclerosis is new or old bone. Weber,³ in 1931, brought out a paper on otosclerosis, in which he discusses at some length the question of fibrils and cement lines and tries to settle the controversy. The main argument of those who contend that otosclerosis is "changed old bone" is that quite often no cement line can be found at the edge of or at certain parts of the edge of otosclerotic foci (cf. Wittmaack⁶). Weber, by the use of polarized light, from which can be inferred the direction of fiber bundles, demonstrated that in no case did the fiber bundles enter otosclerotic foci unless they were projecting peninsulas of the normal endochondrial capsule. He contends that because none of the fine long fibers from the normal capsule can be seen to mingle with the short fibers of the typical otosclerotic focus, it is impossible to conceive of the pathologic process being metaplasia of the normal bone of the capsule. It must therefore be new bone.

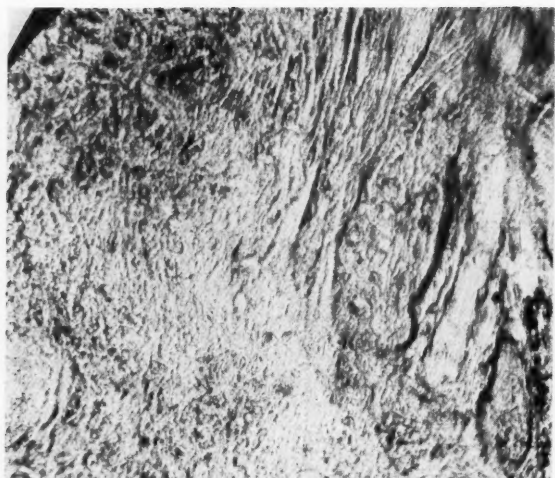


Fig. 3. Middle of otosclerotic area in ultraviolet light. Note irregular structure of short fiber web bone—bundle of parallel fibers below and to left of center—also red blood cells in upper left-hand corner. (6 mm. Obj. 5x ocular x250.) Case No. 11143.

Unfortunately, in order to visualize fibers in polarized light they must make some sort of a grating—that is, they must either all be parallel, or they must be arranged in bundles which contain parallel fibers. Very loose, irregularly arranged fibers do not change the direction of the polarized light at all, so that it is really impossible to be positive by using polarized light that individual fibers do not penetrate into otosclerotic foci. There is a further difficulty in that, if the fibers of the normal capsule should happen to be cut vertically instead of longitudinally, they would not change the plane of the polarized light either. Such areas are very difficult to distinguish from otosclerotic areas unless the otosclerotic area is made up of dense bone such as the lamellar bone which often occur in old foci. All in all, the use of polarized light is not conclusive.

Let it not be understood from this that I disagree with Weber's conclusions as to whether otosclerosis is new or old bone. I am merely pointing out the limitations of the use of polarized light.

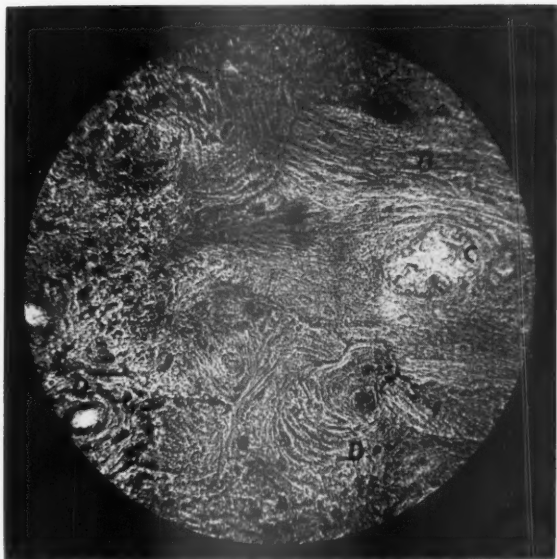


Fig. 4. Edge of otosclerotic area in ultraviolet light. Note *A*, short fiber web bone; *B*, parallel fiber bone or "skein bone" of normal capsule; *C*, cartilage-like island; *D*, irregular lamellar or "shell bone." (6 mm. Obj. 5x ocular, x250.) Case No. 10576L.

When the edge of an otosclerotic focus is studied in unstained sections in ultraviolet light, the line of demarcation made by the difference in fiber structure is usually apparent at once, and the direction of the individual fibers can be seen rather than inferred, even under the lower powers (Fig. 4). There are, however, a few areas in which the line of demarcation is not so very clear. This is especially true when an otosclerotic focus is juxtaposed to periostially formed bone (Fig. 5). Although cement lines are present, often one cannot be sure whether a given cement line is the edge of an otosclerotic focus or whether it is the cement line of an Haversian system within the focus, or a system in the periosteal capsule. There is sometimes a clue. When due to repeated infections of the middle ear, many superimposed cement lines are present in the promontory; these are then sharply cut and so demonstrate the line of demarcation. In the portion of



Fig. 5. Otosclerosis. *B*, juxtaposed to periosteal bone—*A*—and "skein-like" bone of endochondrial capsule, *C*. (6 mm. Obj. 5x ocular x250.) Case No. 10576L.

the labyrinthine capsule where the bone fibers run in parallel fashion, the "skein-like fiber bone" of Max Meyer,⁷ a line of demarcation is obvious (Fig. 6). Occasionally fibers seem to enter an otosclerotic focus under lower powers, but with the higher powers they are found to be merely shelves. None of the parallel fibers of the normal capsule have ever been observed to enter otosclerotic foci. Rarely the fibers seem to enter and invade the cartilage-like islands (Fig. 7).

In studying the presumably normal portion of the temporal bone in ultraviolet light one comes upon areas in the capsule which contain a type of bone similar to that often found within otosclerotic foci. The fibers in these areas are short and loose. The cells were large and their canaliculi run in all directions. Occasionally two cells are seen within the same lacunar space. The areas stain a somewhat deeper blue with hematoxylin and are undoubtedly

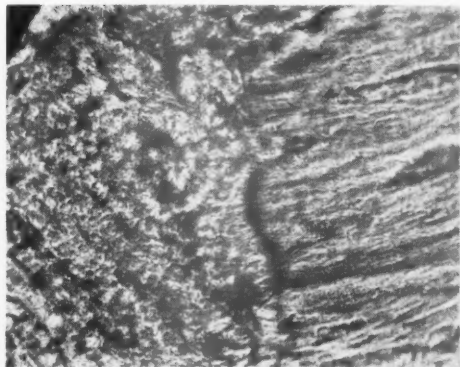


Fig. 6. High power of edge of otosclerotic focus. Same field as upper part of Fig. 4. Glycerin immersion. 1.7 mm. Obj. 5x ocular x1400.

the "blue mantles" of Mannasse. They occur about blood vessels and have irregular borders suggestive of the Howship's lacunae of previous absorption. These areas seem to be numerous in cases of otosclerosis, but they have also been found to be very numerous in cases of otitis media, either active or healed. Similar bone has been removed from the nose in a case of chronic sinusitis. This leads to the conclusion that short fiber web bone may be produced by a chronic process in the labyrinthine capsule outside the sight of predilection for otosclerosis. A parallel may be drawn in the increase of connective tissue cells in the mucoperiosteum of the ear with chronic inflammatory disease. After all, bone is merely a modified connective tissue.

COMMENT.

The fact that more secondary bone formation is found throughout the labyrinthine capsule of cases with evidence of previous inflammatory reaction, emphasizes the suggestion of Dr. E. P. Fowler, Sr.,⁸ that previous inflammation may well be of primary importance in the production of otosclerosis. The contention that otosclerotics never have middle ear disease is invalid. The diagnosis of otosclerosis is not made in the presence of middle ear dis-



Fig. 7. Edge of otosclerotic area entering cartilage-like island. Note "skein-like" parallel fiber bone of normal capsule above. (6 mm. Obj. 5x ocular x250.)

ease. In fact, the only people who are diagnosed as otosclerotics are those who have no history and few signs of previous otitis. This makes the clinical incidence of the disease small. Pathologic material shows that otosclerosis and otitis media very often occur together and the incidence of the disease is very high (5 per cent of routine autopsies in my series, also cf. Mayer¹). Furthermore, some degree of middle ear disease occurs in all individuals, whether it becomes apparent through pain and discharge or not. All of us have seen heavily scarred and retracted drums in individuals who claim that they never had any middle ear disease. Milder involvement would be even more difficult to remember. The only cases now diagnosed as otosclerosis clinically are those whose otitis was so masked as to make it seem inconsequential. As shown in Fig. 2, ultraviolet photomicrographs of the bone found in the mastoid or elsewhere

after a chronic inflammatory process shows a primitive type of bone similar to that found in otosclerotic foci. This type of bone is also formed in the kidney when the renal vessels are tied off in a rabbit (Asami and Dock⁹). It is found in all kinds of pathologic bone growths; it is found in healing fractures.

If inflammatory disease has anything to do with otosclerosis, its probable rôle is a thrombosis or stasis of the vessels leading to or draining the area involved, rather than a direct invasion of the wall, for otosclerotic foci never show the many leucocytes and the exudate of a suppurative process. Furthermore, an identical process has been actually produced in hens by Wittmaack,¹⁰ who upset the venous drainage to the capsule with iron chloride. This makes a large thrombus in the torcula, resorption of bone takes place throughout the areas drained, and then new short fiber web bone is laid down. The resorption stage of otosclerosis has not been emphasized in this paper because the ultraviolet microscope brings out nothing new in these areas, but, after all, it is the primary lesion and should not be forgotten. Incidentally, as an added point for the theory that otosclerosis is caused by a local process, all attempts to cause it experimentally by general means have resulted in more resorption and then later more bone regrowth in other bones of the body than the labyrinthine capsule (cf. Gale and Jaffe,¹¹ on the labyrinthine capsule of guinea pigs injected with parathormone, Weber,¹² on the labyrinthine capsule of dogs fed on low calcium diets). I have had a similar experience in the study of dogs and rats on low calcium diets.

SUMMARY AND CONCLUSIONS.

We come, therefore, to the conclusion that otosclerosis is a reaction to a local process, possibly a thrombosis of vessels on the promontory or elsewhere in the course of a known or "masked" otitis media. Some resorption and regrowth of bone is to be seen in other parts of the labyrinthine capsule than the sites of predilection. This indicates, as one might expect, that interference with the blood supply to the bone in other areas also produces resorption and regrowth of bone. It is only the unprotected location of the anterior part of the niche for the stapes, the probability

that its blood supply would most easily be affected, its bazar normal structure and the fact that it may cause symptoms which make otosclerosis stand out so prominently here. Also there is a strong probability that predisposed individuals might have vessels in this region which were more open to attack or have anastomoses insufficient to provide for the emergency of thrombosis of the vessels over the promontory.

In ultraviolet light the fiber structure of otosclerotic foci shows it to be a new bone, often as primitive in type as the bone of the normal endochondrial capsule. Later this primitive bone may be partially replaced by a lamellar or "shell" type of bone, but this is not the initial process. The important point is that the first bone formed is similar to that of a healing process in any other bone of the body which has been injured, irritated by infection or resorbed by interference with its blood supply.

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XXXI.

LATERAL SINUS THROMBOSIS WITH A REVIEW
OF THE LITERATURE.*

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This study represents a comprehensive analysis of the complications of lateral sinus thrombosis based on the experiences of Dr. G. M. Coates, Dr. M. S. Ersner and their respective staffs both at the Graduate Hospital and the Mt. Sinai Hospital in Philadelphia.

The resumé is deduced from a series of 969 mastoidectomies that were performed in these respective hospitals between January, 1922, and January of 1933, and also includes certain evidence previously reported by the authors in April, 1930, and in July, 1931.^{1 2}

This series of mastoidectomies is classified in the following table:

	Simple	Bilateral	Radical	Total
Males.....	347	49	74	470
Females	304	40	66	410
	651	89	140	880
			Plus Bilateral	89
Total number of operations				969

In the above series there were 14 cases of lateral sinus thrombosis, or 1.4 per cent. This percentage seems to be in keeping with a great many authors. White³ reports 1.8 per cent of sinus thrombosis in a series of 588 cases of mastoiditis. Wanamaker⁴

*Read before the Philadelphia Laryngological Society, April 3, 1934.

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notes that in general, lateral sinus thrombosis occurs in from 3 to 6 per cent of operative cases, and he notes the finding of seven cases in 166 mastoids by Hill; five cases in 78 mastoids by Downey; 25 cases in 524 mastoids by Garber; 3 cases in 100 mastoids by Welty; 19 cases in 497 mastoids by the Massachusetts Eye and Ear Infirmary; 6 cases in 192 mastoids by Naftzger.

Of our fourteen cases, nine recovered and five died, a mortality rate of 35.7 per cent. However, this figure should be modified, for of the five deaths there were three cases that presented more serious complications on admission to the hospital, hence they were not cases of simple lateral sinus thrombosis. Of these three, there were two cases of meningitis and one case of brain abscess. If we exclude these three cases we find that the mortality rate is 14.3 per cent. Our study pertains to actual cases of lateral sinus thrombosis and does not include such conditions as perisinus abscess nor lateral sinus phlebitis wherein there was the typical spiked temperature with the presence of chills and even a positive blood culture, but that had recovered spontaneously after a simple mastoidectomy, with or without exposure of the sinus, being augmented perhaps with only blood transfusions, intravenous therapy (chemical and biologic), and other supportive measures.

In a study of this character which will bring into the discussion a great many features, perhaps it may be best to begin by describing first the salient features in anatomy.

It is a well known fact that the right lateral sinus is more frequently affected than the left. There may be certain anatomic reasons for this. In Piersol's Anatomy⁵ we find the following description, viz.: starting at the meeting point of the five cranial sinuses (i. e., superior longitudinal, the two lateral, the straight and the occipital), at the torcular herophili, each lateral sinus passes outward over the squamous portion of the occipital bone, along the line of attachment of the tentorium cerebelli and passing over the posterior inferior angle of the parietal bone, is continued inward upon the inner surface of the mastoid portion of the temporal bone and the jugular process of the occipital bone to reach the jugular foramen, where it opens into the internal jugular vein.

A difference in size is usually noticeable in the sinuses of the opposite sides, that of the right being usually larger, and this difference is due to the mode in which the various sinuses meet at the torcular herophili. Most frequently the superior longitudinal sinus communicates mainly with the right lateral, while the straight sinus opens principally into the left. The greater amount of blood being carried by the superior longitudinal sinus as compared with that transmitted by the straight sinus. In some cases the right lateral sinus is practically a direct continuation of the superior longitudinal sinus, and left lateral sinus of the straight; the two lateral sinuses being connected only by a short, relatively small connecting arm which represents the torcular herophili. The knee of the sigmoid portion of the lateral sinus extends further inward and forward on the right side than on the left, and this fact, together with the larger size of the right lateral sinus as compared with the left suggested to Piersol the explanation of the greater frequency of sinus thrombosis as a sequel to a right-sided otitis media. Seydell⁶ states: "The right lateral sinus, which is usually larger than the left, usually lies deeper in the mastoid bone, and consequently comes into closer contact with the mastoid cells and so may become infected by continuity of structure. In addition to the variations in the position of the sinuses, there are numerous anomalies, i. e., there may be (1) an entire absence of one lateral sinus—usually the left; (2) the horizontal part of the lateral sinus may be absent, the sigmoid portion being a continuation of the superior petrosal sinus; (3) there may be a formation of two horizontal portions; (4) two sigmoid sinuses may sometimes be present on the same side." Kopetzky⁷ quotes Law,⁸ who described an anatomic specimen of a right temporal bone which showed a strongly developed emissary vein running upwards and posteriorly in a sulcus 6.5 mm. in width. The sulcus of the sigmoid sinus was completely absent. The blood from the right transverse sinus emptied into the right emissary vein and not into the jugular bulb. From the emissary vein the communication was with the superficial cervical veins direct. The left sigmoid sinus was markedly developed. In addition the right middle and posterior cranial fossæ were smaller than on the left. Ersner and Myers,⁹ in an exhaustive study, have

emphasized the importance of the difference in size of the two lateral sinuses. They have three cases in which the lateral sinus was absent on one side and a fourth case in which there was a marked difference in the sizes of the two sinuses. Körner¹⁰ states that the cranial fossa is higher on the right side than on the left and offers the suggestion that this may be an added factor for the increased frequency of the inflammation of the right sinus over the left.

According to Piersol, the diameter of the right sinus is from 9 to 12 mm., while that of the left is from 3 to 5 mm. In our series we noted the practical equality in the diameter of the two sinuses, there being a variance of only 1 mm. in three cases of the fourteen, and the size of the sinus varying from 6 to 10 mm. in diameter. These measurements were taken from the X-ray films prior to operation. Another thought as to the prevalence of the right-sided over left-sided thrombosis may be deduced from the fact that in as much as the right lateral sinus is larger than the left, the rate of flow of the blood is slower, hence when the infection enters through the intima of the lateral sinus it is more likely that the thrombus will form with the slower blood current. As Ersner and Myers have noted, where there is a marked difference in the size of the two sinuses there may be an inability of the smaller sinus to properly handle this excessive collateral circulation and so tend to slow the blood current, and in this way form another tendency or predisposition favorable for thrombus formation.

In our series there were eight cases of right-sided sinus thrombosis with six on the left side. There was an equal distribution in the sex, that is, seven males and seven females, although Lebert, Hessler, Jansan and Forselles¹⁰ have noted that males were found to be three and one-half times more frequently affected than females.

Pathology.—Again quoting Seydell,⁶ he noted that in the great majority of cases involvement of the lateral sinus is caused by the direct extension of the infection within the mastoid process. In these cases the bone may show no macroscopic changes but, on the other hand, may be found softened and partially necrotic. At times only one or two perisinus cells may show involvement,

with little infection in the remainder of the mastoid. In all of these cases there are usually some changes in the sinus wall. This variety of thrombosis has resulted from extravenous extension. We may also have a thrombosis by intravenous extension. This means an extension through a tributary vein. Here a thrombus forms in a smaller vein and gradually extends into a larger one until finally the extension reaches a sinus. A peripheral thrombus is formed and, if conditions are favorable, the entire lumen of the sinus may become blocked. In these cases the outer sinus wall may appear normal. The presence of pus, plus the pressure of a perisinus abscess with its granulation tissue, may very easily produce a sinus thrombosis. There are two theories relative to the formation of thrombi: (1) Talkes¹¹ and others hold that it is not necessary for the bacteria to penetrate to or through the intima. The chemicotoxic action of germs present in the wall of the sinus may produce the clot. (2) Leutert¹² and others hold that inflammatory changes in the intima are necessary and that germs produce toxins which lower the bactericidal properties of the blood, making thrombus formation easier and that all thrombi are infected from the beginning.

Haymann¹³ has shown by his experiments that either or both methods may produce a thrombus and that thrombi may be sterile at first and later become infected. The formation of thrombi is a protective measure; he found that marked changes may occur in the intima without the production of a thrombus, but in these cases the endothelium remains intact. Therefore, in his opinion, a lesion of the intima is necessary for the production of a thrombus.

At first we find a small accumulation on the sinus wall which soon develops into a mural thrombus. The current of the blood stream is slower along the walls of the sinus, a condition which aids in the development of the thrombus. The thrombus usually begins on the outer wall, but under certain circumstances, may arise from the inner wall. A mural thrombus may remain as such or, by the accumulation of fibrin, white and red corpuscles, and platelets, may form an obturating thrombus. A parietal thrombus may or may not be infected, and in either case may or may not produce emboli. There is always a tendency towards

organization of thrombi and this may take place in one portion of a thrombus while in another portion purulent degeneration may be found. A parietal thrombus may, of course, cause a systemic infection, but according to Haymann, due to its early organization, it is rarely the cause of a long drawn out sepsis. An obliterating thrombus is usually laid down in layers. Here organization and suppurative destruction take place at the same time.

A thrombus may develop either in a central or in a peripheral direction. The thrombus may even extend to the opposite side, or it may extend downward into the subclavian vein. Thrombi may be sterile. In fact, the appearance of a thrombus does not indicate whether it is infected. The ends of the thrombus are more or less pointed, redder in color, and are usually less infected than the center of the thrombus.

Bruner¹⁴ and later Boies¹⁵ have attempted to differentiate between three different types of lateral sinus thrombosis. Quoting Boies: "Lateral sinus thrombosis may be (1) present at the time of primary operation on the mastoid, with evidence of its existence; (2) latent, in that it becomes manifest because of the operation, or (3) postoperative, developing entirely in the period after operation. In the latent group, it is assumed that a thrombosis has taken place, but the signs of it are not manifest, and that a continued thrombus formation and the production of symptoms occurs as a result of the "stirring up" due to the operation.

Bruner observes that: "Exposure of a normal sinus during a mastoidectomy has no influence on the incidence of a sinus thrombosis. A periphlebitis may be present which would mask an underlying thrombosis. Occasionally a 'latent' thrombosis may become manifest only by an operative trauma in doing a simple mastoidectomy. In chronic otitis there may occur a "compression" thrombosis, a mural thrombosis originating from the site of a perisinus abscess.

Injury of the sinus wall is more dangerous than mere exposure, and septic phenomena may occur as early as six to eight hours after injury. While injury is a factor, other factors must be present, viz., the presence of highly virulent germs and stagnation of secretion, the latter especially caused by increased formation of granulation tissue and pockets and undermining of the edges

of the wound." He considers the virulence of the organisms a most important factor.

He attempts to differentiate a postoperative sinus thrombosis from a latent condition: (1) Absence of all symptoms of thrombosis before operation on the bone and the long interval (usually two weeks) between exposure of the sinus and the first appearance of symptoms of thrombosis; (2) no evidence of thrombosis found at operation while extensive thrombosis is usually found in latent forms.

Another question is the relation of lateral sinus thrombosis to the various types of mastoid infection. In our series we have found at time of operation that the lateral sinus thrombosis appeared in nine cases of acute mastoiditis, usually of the hemorrhagic or the coalescent type. There were two cases of subacute mastoiditis and three cases of chronic mastoiditis. Rueg¹⁶ found that in a series of 81 cases of sinus thrombosis 43 occurred in the acute and 38 in the chronic. Bruner¹⁴ had 22 cases; 12 in acute and 10 in chronic mastoiditis.

Synptomatology.—The classical symptoms of lateral sinus thrombosis may be grouped under three heads: (1) Those due to systemic phenomena; (2) cerebral, and (3) septic.

1. Systemic phenomena are characterized by the sudden appearance of severe chills or rigor with the sudden unusual rise in temperature to 104° or over and an associated acceleration of the pulse rate. This chill may last five to ten minutes or even longer. The patient is flushed and very often appears acutely ill, although this latter may not be the constant association. Following this chill there is a marked remission which may go down to normal or subnormal, and during this period the patient is apparently rather comfortable and feels well. It may take an hour or two before the temperature returns to normal, or on the other hand, may take several hours. The characteristic "spiked" temperature may recur within twenty-four hours or again it may not recur for two or three days. The recurrences are rather characteristic. However, we may have cases in which the symptoms are atypical or in which there is not the slightest manifestation or suggestion that the case may be one of a lateral sinus thrombosis.

These atypical phenomena may be due to: (1) A sterile clot, (2) a very mild infection or where the organism is of low virulence, and (3) in debilitating conditions, such as old age, diabetes, etc. In case No. 14 of our series we have an atypical type of lateral sinus thrombosis in a patient with diabetes.

The time relation of the onset of symptoms depends perhaps on the period during which the sinus became infected, for as Boies¹⁵ has pointed out, the thrombus may be present at the time of primary operation on the mastoid, or latent, in that it becomes manifest because of the operation, and thirdly, postoperative, occurring some time after the operation. From this it will be seen that there is no specific time relationship of the symptoms to the mastoid infection.

2. Cerebral Symptoms.—The patient will complain of headaches which may be rather severe in type and usually present during the height of the febrile attack. If they occur during the period of remission they are likely to be due to cerebral congestion caused by the obstructive clot. Giddiness, vomiting and nausea may also be present. Ocular symptoms may be found in as high as 25 per cent of cases where there is an obstructive thrombus. These ocular symptoms are manifested by hyperemia of the optic nerve, optic neuritis and even choked disc. In children, due to this cerebral congestion, one may have added such symptoms as convulsions, lethargy and acute meningeal symptoms, as a positive Kernig sign, Brudzinski, etc.

3. Septic Symptoms.—In view of the bacteremia that is present, blood cultures are made routinely. Seydell⁶ stated: "A blood culture is indicated in any case that presents a septic temperature, either before or after operation. It is best to take the culture at the height of the temperature, because a negative culture will often be obtained if taken after the temperature has dropped. When chills occur, the cultures should be taken at the termination of the chill, as at that time the blood is flooded with organisms." Kolmer¹⁷ believes that the quantity of blood taken is of importance. His method is to use 5 cc. of blood to 100 cc. of a special broth medium or 10 cc. of blood to 200 cc. of medium. His recommendation is a hormone glucose blood medium of a Ph of 7.4

to 7.6. It must be remembered that it is possible to have an extensive sinus thrombosis without being able to demonstrate any bacteria in the blood. The ends of the thrombus in these cases may not be infected. When this occurs, one would have a sinus thrombosis with a negative blood culture. One might also have a negative blood culture due to the destruction of the bacteria in the blood. Experiments have shown that in cases of sinus thrombosis more bacteria are found in the blood taken from the lateral sinus than when the blood was taken from the arm. One must never depend upon a negative blood culture. A positive blood culture in the presence of a suppurative ear condition, unless some other focus of infection can be found, should make one very suspicious of the presence of sinus thrombosis or phlebitis.

The presence of bacteremia manifests itself by metastasis to the various parts of the body. Kopetzky¹⁸ has attempted to differentiate metastases: (1) In the superficial structures, such as the skin and the joints, due to one type of an organism; (2) to cerebral structures due to another type of an organism; (3) to vital structures, such as the liver, spleen, lungs, kidneys, etc., due to a third strain of organism. He states: "It does not seem that the distribution of metastatic lesions depends on the character of the lesion in the mastoid, but rather on the type of organism presented and its inherent selectivity. *Pneumococcus* and *streptococcus mucosus capsulatus* invariably affect the endocranium after invading the mastoid. *Streptococcus hemolyticus* shows several strains, one selecting the joints and serous membranes, another the superficial structures, such as the skin and muscles, while still another attacks the lungs. Metastases are not dependent on disorganization of the thrombus and the spread of its particles into the general circulation. The living bacteria themselves escape into the blood stream. These are much finer than any portions of broken down thrombi and can be carried everywhere that the blood reaches." Metastases to the superficial structures, such as the skin and joints, on the whole are favorable complications. They may act in the rôle of "fixation abscesses" and so perhaps stimulate the defensive mechanism of the body. The literature is replete with instances wherein are reported recoveries from severe cases of lateral sinus thrombosis that had metastases to the skin

and joints. In our series we had two such cases that recovered and one that died. Our impression is that when we have such a superficial focus of metastasis the prognosis perhaps is just a little more favorable.

On the other hand, where metastases occur in the more vital structures, such as the brain, the kidneys, liver, spleen and lungs, the prognosis is grave; with the single exception of where a focus is localized in the lungs alone, we occasionally may give a guarded prognosis.

Diagnosis.—The diagnosis of lateral sinus thrombosis depends on both the general and laboratory grouping of symptoms.

A, General—When in the course of an otitis media, acute or chronic, or in the course of mastoiditis, we find a sudden rise of temperature to 104° or over with a rapid pulse rate associated with chills, rigors, headaches, nausea and even vomiting, our suspicions are aroused that we may be dealing with a lateral sinus thrombosis. Now if to these symptoms we may have some added eye symptoms, such as the prominence of the retinal vessels, papilledema, choked disc, or even a true optic neuritis, and other local symptoms, our deductions are intensified. Among these local conditions we may add (a) Griesinger's sign. This is an edematous swelling over the mastoid region which spreads up towards the temporal region and often to the eyelids. This is perhaps due to a thrombosis of the emissary vein or to an engorgement of the veins that drain into the internal jugular vein. (b) If the thrombus had formed and extended down into the internal jugular vein one may be able to elicit, by palpation, a tough band in the course of the jugular vein, i. e., along the anterior border of the sterno-cleido-mastoid muscle. This band is rather tender and firm to the touch and an inconstant finding.

B, Laboratory Aids.—Perhaps the most important laboratory finding in lateral sinus thrombosis is due to the bacteremia. Hence we look for a positive blood culture. A positive blood culture of course leads to a positive diagnosis. Where the blood culture has been negative and the symptoms still persist, it is well to repeat the procedure within twenty-four to forty-eight hours, and frequent blood cultures are indicated for as long as the elevated tem-

perature and chills persist. Ottenberg¹⁹ has attempted the procedure of examination of the blood directly from the two internal jugular veins. He takes blood from each vein, plates this blood and counts the colonies of bacteria from each vein. He has deduced that the side which gives the lesser number of colonies is the side where the thrombus was present. And he believes that the systemic invasion is from the torcular end of the sinus and not from the bulbar end. This work (counting colonies) has also been done by comparing the blood taken from the two brachial veins. This method of differentiation is particularly valuable where there is the presence of a bilateral mastoiditis and when one is at a loss to determine on which side there may be a thrombus.

Another test is the Ayer-Tobey modification of the Queckenstedt test. This test depends upon the increase of the spinal fluid pressure in the presence of an occluding thrombus when digital pressure is applied to the uninvolved jugular vein. While it is of extreme usefulness in many cases, the literature contains any number of instances where this test has been unreliable. Its reliability is particularly marked in the presence of an occluding thrombus, but when the thrombus is only mural there is an opportunity for a certain percentage of error. We have employed the test in a number of our cases and we feel that it is of actual value only in addition to other clinical symptoms. A negative result does not obviate the presence of a thrombus. Where there is a small sinus on one side there is another chance for an erroneous deduction in the Ayer-Tobey test. Normally if one lateral sinus is smaller than the other, pressure on the jugular vein of the smaller side will give a negative reading, while pressure on the vein of the larger sinus will give a higher manometric reading. Pathologically if the smaller sinus is involved, a negative reading will be obtained without pressure; but if the wider sinus is involved, then there is frequently an elevation of the pressure, even though no compression is made to the vein; and lastly, if pressure to the vein is applied the manometric reading will be much higher. When the sinuses are of comparatively equal size on both sides and there is an occluding thrombus on the one side, compression of the jugular vein of the opposite side very frequently gives an elevation in the manometer reading and is diagnostic of a throm-

bosis on the affected side. This test should be of particular value in cases of bilateral mastoiditis where one is at a loss to determine the possible infection of either one sinus or the other.

Blood Examination.—The blood count is an excellent indicator that some complication is present, but there is a great question of doubt as to its being of diagnostic value. An increase in the total number of leukocytes indicates a more severe infection than a mere mastoiditis. A fall in the hemoglobin indicates a hemolytic process. Unfortunately the group of cases that we are presenting did not have the benefit of more recent laboratory examinations such as the Schilling hemogram, the degenerative index and the sedimentation rate, and consequently we cannot say more than that from the observations of other investigators, the Schilling index alone or with the degenerative index (where there is a relation between the polymorphonuclear cells showing toxic granules and vacuolization to the normal polymorphonuclear cells) are of slight diagnostic value but a more definite aid in prognosis. Due to numerous extraneous factors that have a tendency to influence the sedimentation rate ordinarily, this criterium is of lesser importance in diagnosis or even in prognosis.

Treatment.—The treatment of lateral sinus thrombosis is both supportive and operative. Supportive, since we are dealing with a bacteremia or septicemia and one must employ all possible means for ameliorating and controlling this infection. The vital resistance of the patient must be maintained. In order to effect this the most common method is the use of blood transfusions. It is immaterial whether one uses the whole or the citrated blood in transfusions. Short transfusions, anywhere from 150 to 250 cc. of blood, are preferable and should be repeated at frequent intervals, particularly where the infection is very severe. (In children and infants one may use 1 to 1½ cc. of whole blood per pound of body weight.) They may be repeated from once every other day to once a week. It is not of any special significance whether a secondary anemia that may be present be mild or marked. Some authors feel that a transfusion is indicated only when there is a marked secondary anemia. The purpose of the transfusion is to introduce new blood with increased oxygen carriers and so to increase the bactericidal action, and secondly to dilute the infect-

ing organisms present. The transfusions may be used either pre- or post-operatively. Post-operatively they are indicated wherever the clinical course is not satisfactory as manifested by the persistent septic type of temperature, by increasing anemia, or a marked loss of resistance. Tillie²⁸ also noted that a transfusion from a purposely immunized donor should be particularly effective, but this was not borne out clinically by him. On the other hand, Ersner and Myers²⁹ have immunized their donors with 1/10 cc. of a stock vaccine of typhoid bacilli containing 50,000,000 killed organisms. This produced a severe reaction in the donor, and seven to eight hours after immunization they withdrew several hundred cc. of blood from the donor, and of this gave 100 cc. or more of whole blood to the patient. The rest may be citrated and kept in the ice box until further use. They reported excellent results from this modification. In addition to blood transfusions, our treatment was augmented by the use of various intravenous medicaments—Pregl's iodine, 10 to 20 cc., given intravenously daily is an excellent adjunct to blood transfusions; neutral acriflavin, 1 to 500, has also been used either alone or alternating with Pregl's iodine; mercurochrome has been used, but we have had no gratifying results with this solution. Other members of the anilin group have also been used, but all with varying success. Metaphen has been tried in this treatment. Serum treatment, particularly in streptococcic infections, has been employed. Ersner²¹ has used Dick's antiscarlatinal serum with some gratifying results. Polyvalent antistreptococcic serum has also been used. Kolmer and Amano²² suggest that in the pneumococcic type of a mastoiditis the use of an autogenous vaccine made of a culture from the mastoid wound is also of benefit. The use of any of these sera must be employed cautiously since anaphylactic reactions may be quite severe.

B. Operative.—The operative procedures employed are primarily the removal of the focus of infection, and secondly an attempt to limit the spread of the infection from extramastoid areas. The opening of the lateral sinus with the removal of the clot and the attempt to obtain free bleeding from both ends of the sinus should be done in all cases. This may be rather difficult at times when the thrombus extends all the way back to the tor-

cular or down into the bulb of the jugular vein. One must do as much as possible.

The question of the treatment of the jugular vein has received a considerable amount of discussion in the present literature. The tying of the jugular vein with the thought that this would prevent the spread of the infection throughout the system, particularly in the mediastinum, has been employed for a great number of years. Recently a good deal of work has been done in an attempt to treat sinus thrombosis without tying or cutting the jugular vein and the reports are quite varied. Rott,²³ in an extensive study, cites the work of Körner, who found no apparent differences in the results in two series of cases; one in which the jugular vein was ligated and the other series where the jugular was not ligated. Körner's results are 58.3 per cent cures without ligation, 59.6 per cent with ligation before the sinus was opened, and 59.9 per cent of cures in cases where the jugular vein was ligated after the sinus was opened. Jones,²⁴ in an analysis of fifty cases, did not discover any difference in the mortality rate in the two procedures. Krepuska²⁵ reported 196 cases of sinus thrombosis that recovered in a series of 295 cases, of which 138 had the tying of the internal jugular vein. Grunberg reported twenty patients in which the jugular vein was tied and forty-one where it was not tied. Of the first group, 15 per cent were cured, and of the latter group 60 per cent were cured. Rott classifies four types of cases: (1) That of the hemorrhagic mastoiditis where the thrombotic process starts in the veins of the mucosal lining and extends from this to the larger veins in the bony cell wall, and presents a course of symptoms that resembles very closely the clinical course of a true lateral sinus infection, even to the point of having a positive blood culture. He states that in this case it is only necessary to do a complete exenteration of the mastoid cells. (2) The second class of cases is where there is an infection in the outer sinus wall. Here all that is necessary is the removal of the bony plate of the sinus. (3) The third class of cases is where there is a real infection inside of the lateral sinus with thrombus formation, and treatment consists of incision of the sinus, removal of the infected pus or thrombus, and the establishment of free bleeding from either end. (4) The fourth class of cases con-

sists of those in which the infection has been removed from the lateral sinus or in which an obliterating thrombus prevents free bleeding from the region of the bulb. He quotes Dixon:²⁶ "Tying of the internal jugular does not stop the septicemia and simply adds another hazard for the very sick patient. I have seen just as many patients with septicemia wear out their infection with ligation of the internal jugular vein as without it." Rott's conclusions are: "(1) The only indication to be met in the treatment for lateral sinus infection is the prompt removal of the infected area, whether that area is in the mastoid cells, the sinus plate, the wall of the sinus or inside the lumen of the sinus. (2) Ligation of the jugular vein does not prevent the absorption of toxins and bacteria into the general circulation and hence is a superfluous procedure. (3) Ligation of the jugular vein should be reserved for definite infection in the vein, and then should be accompanied by resection."

In our own series, as is shown by our table, there were two cases where the lateral sinus was opened but not ligated. A third case where the sinus was opened without ligation and intravenous injections of metaphen were added. These three cases fully recovered. In seven cases the jugular vein was ligated and cut, and four cases in which not only was the jugular vein ligated and cut but in addition the facial vein was ligated. As also will be seen from the table, transfusions and various intravenous medicaments were employed. Kopetzky²⁷ quotes Pagano, who feels that jugular ligation is the most important feature in stopping the spread of the infection and considers this the best method of attacking the lesion. Kopetzky also feels that it is more important to rid the lateral sinus of the focus of infection, and tying the jugular vein in all cases except those in which there is an obliterating clot. Our own conclusions are that it is perhaps better to ligate the jugular and add the necessary supportive treatment. This thought is actuated by a feeling that one should be freed of any self-reproach, criticism or condemnation when the case does not recover. There will always be a certain percentage of our cases that will recover, no matter how little we do. This may be due to a splendid resistance on the part of the individual or a low virulence of the infecting organism. On the other hand, there

Case No.	Name	Age	Sex	Past Otitis	Signs	Size of sinus in mm.	
1.	R. K.	3½	M.	1 week	Discharge left ear	.....	.....
2.	P. H.	18	F.	10 days	Discharge right ear	.....	.....
3.	C. R.	5	F.	4 weeks	Discharge right ear	.....	.....
4.	M. C.	55	F.	6 weeks	Discharge right ear	7	7
5.	F. W.	6	M.	6 weeks	Discharge right ear	9	9
6.	D. S.	15	M.	5 days	Discharge right ear, Kernig's headache	.....	.....
7.	A. T.	13	F.	10 days	Papilledema dis- charge left ear	9	9
8.	J. M.	41	M.	?	Discharge left ear	10	10
9.	J. M.	26	M.	4 weeks	Discharge right ear	.....	.....
10.	W. K.	5½	M.	4 days 6 days mastoid	Discharge right ear	7	7
11.	M. McE.	17	F.	12 years	Discharge left ear	8	9
12.	N. C.	8	F.	8 years	Discharge left ear	.....	.....
13.	L. Z.	11	F.	3 weeks	Discharge left ear	.....	.....
14.	H. R.	52	M.	5 weeks	Discharge right ear	8	9

Case No.	Meta-stasis	Symptoms	Blood Culture	Operative Findings Mastoid
1.	Right buttock	Chills, fever 106° 8 days after operation	+ 700 — 900 Streptococcus Hemolyticus	Acute—cavity formation
2.	.....	Chills, fever 3 days after operation	+ Streptococcus Hemolyticus	Hemorrhagic—necrosis at tip
3.	.....	Chills—fever	+ Streptococcus Hemolyticus	Coalescent with necrosis
4.	.....	Fever, chills, headache 11 days; mastoid 1 month ago	None	Acute
5.	.....	Headache	.....	Subacute, cavity formation; thrombosis found at operation
6.	Forearm	.....	+ non-Hemolyticus (3) Streptococcus	Acute perisinus abscess necrosis in sinus
7.	.....	Slight stupor, rigidity of neck	.....	Chronic suppuration, extra dural abscess
8.	Right arm, shoulder, lungs, neck	Chills and fever 5 days after operation	Negative	Acute
9.	.....	Chills on admission; fever for several days	Negative	Chronic
10.	.....	Chills—fever, Ayer Tobey Test	Streptococcus Hemolyticus	Simple acute hemorrhagic
11.	.....	Headache, vomiting; nausea 5 days	Negative	Chronic temporo-sph. abscess
12.	.....	Chocked disc, pain; chills 2 days after oper. + Kernig's pre-oper.	Negative	Subacute
13.	.....	Fever—no chills	Negative	Acute
14.	.....	.....	Streptococcus Hemolyticus	Acute; lateral sinus plate necrosed, broken down clot

Case No.	Sinus	Treatment	Therapy
1.	Intact	Opening of sinus, ligation and cutting of jugular vein, ligation of facial	3 transfusions Pregl's Iodin acriflavin
2.	Exposed	Opening of sinus, ligation and cutting of jugular vein, ligation of facial	3 transfusions Pregl's Iodin acriflavin
3.	.....	Opening of sinus	.....
4.	Necrosed sinus plate	Opening of sinus, ligation and cutting of jugular vein	.....
5.	.....	Opening of sinus, ligation and cutting of jugular vein	.....
6.	Necrotic sinus plate	Opening of sinus, ligation and cutting of jugular vein	5 transfusions
7.	.....	Opening of sinus, ligation and cutting of jugular vein, ligation of facial	Pregl's Iodin Intra. carotid injections
8.	Intact	Opening of sinus, ligation and cutting of jugular vein	1 transfusion
9.	.....	Opening of sinus, ligation and cutting of jugular vein	Metaphen 10 c.c.
10.	Intact	Opening of sinus	Metaphen
11.	Exposed	Opening of sinus, ligation and cutting of jugular vein	Pregl's Iodin
12.	Exposed	Opening of sinus, ligation and cutting of jugular vein	Transfusion Pregl's Iodin
13.	Exposed, 2nd operation	Opening of sinus, ligation and cutting of jugular vein, ligation of facial	Transfusion Pregl's Iodin
14.	Necrosed sinus plate	Opening of sinus	None

Case No.	Type	Blood Culture	Postoperative Fever	Complications Therapy	Results	No.
1.	None	----	-----	-----	Cured	61647
2.	None	----	-----	-----	Cured	55943
3.	None	----	-----	-----	Cured	55639
4.	None	----	-----	-----	Cured	84374
5.	None	----	-----	-----	Cured	78299
6.	Septicemia	+	Fluctuating chills	4 trans- fusions	Died	79421
7.	Meningitis	----	Fluctuating	Injections in 2 carotids, 10 c.c. P. L.	Died	100,650
8.	Pneumonia	----	-----	-----	Cured	42051
9.	Brain abscess	----	High fever, low pulse	Tapping of abscess	Died	50033
10.	None	----	-----	-----	Cured	52630
11.	Brain abscess at operation	----	-----	Tapped	Died	54033
12.	Meningitis before operation	----	-----	-----	Died	54802
13.	None	----	-----	-----	Cured	59074
14.	Tuberculosis, hypertension, diabetes	----	-----	-----	Cured	60133

will always be a group that will do badly. It is in this group that one must employ every and all procedures conceivable in the hope of effecting a recovery, so that should these cases eventually succumb we can console ourselves (small consolation) with the thought that everything possible has been done and that the inevitable had to occur.

Mortality.—As we have noted above, our mortality rate is 14.3 per cent. Our deaths occurred in cases in which everything possible was done from a therapeutic standpoint, including the ligation and cutting of the jugular vein.

SUMMARY.

In a study of sinus thrombosis certain factors appear worthy of emphasis:

1. Anatomically the right sinus is larger than the left. One sinus may be absent. The left may be so much narrowed as to be a serious factor when one contemplates ligation and other surgical procedures. The danger of interference of collateral circulation must be borne in mind. Ersner's work should be carefully noted and, with this thought in mind, it is important to carefully study the relative size of the two lateral sinuses and the jugular foramina, both from the standpoint of operative procedure (ligation of the jugular) and from the prognostic standpoint. The matter of collateral circulation consequently is of particular importance.
2. Atypical symptomatology may be due to anomalies in the sinus structure, involvement of the bulb, as a primary bulb thrombosis, involvement of the petrosal and other sinuses, and lastly, due to infections by organisms such as the streptococcus mucosus capsulatus.
3. Blood examinations, including Schilling hemograms and sedimentation tests, are valuable adjuncts to diagnosis, but especially to prognosis.
4. The Ayer-Tobey test is very valuable, but must be used only in conjunction with other findings to establish a positive diagnosis.
5. Ligation of the jugular vein with exenteration of the infected sinus is the generalized mode of therapeusis. To this is added

small, frequent blood transfusions and intravenous therapy of such medicaments as Pregl's iodine, neutral acriflavin, metaphen, mercurochrome, etc. Dick's scarlatinal and polyvalent antistreptococcal sera should also be included.

6. Metastatic abscesses to superficial structures have usually a favorable prognostic value.

CONCLUSIONS.

1. In our series of cases there were 1.4 per cent of lateral sinus thrombosis.
2. There was a mortality rate of 14.3 per cent.
3. The prevalent organism was the streptococcus hemolyticus.
4. Complications arising increase the gravity of the condition, and where they spread to the meninges or the brain are especially ominous.

1721 PINE STREET.

1915 SPRUCE STREET.

1922 SPRUCE STREET.

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XXXII.

POSTANGINAL SEPSIS.*

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Postanginal sepsis, also called postanginal pyemia, or septico-pyemia after angina, has received considerable attention, mostly in the otolaryngologic literature. Occasionally I have encountered septic conditions which have suggested a septico-pyemic state, following tonsillar and pharyngeal infection, in infants and young children. In order to satisfy my interest and curiosity I have instituted a personal inquiry among pediatric colleagues, who have had a large experience in the treatment of septic sore throats as well as scarlet fever, and I have also made a survey of the literature in order to determine the frequency with which these cases of postanginal sepsis occur among infants and children, and also the course, nature and treatment of this complication.

So far as can be ascertained, the first recognized case of post-anginal sepsis was described by J. W. Long,¹ in 1912. This patient suffered from a tonsillitis; on the fourth day of the illness chills and irregular temperature developed. Several days later it was found that the patient was blind in the left eye due to hemorrhage in the vitreous humor. Long explained the eye symptoms by the presence of thrombi in the cavernous sinus which apparently had extended from the internal jugular vein through the inferior petrosal sinus.

The internal jugular vein was dissected out. It was distended and indurated, and its numerous branches were similarly involved. The vein was ligated and its larger tributaries, such as the facial and thyroid veins, were also isolated and ligated. The excised veins showed numerous thrombi containing pus and streptococci. The patient recovered after a protracted convalescence.

*Presented before the Middle Section of the American Laryngological, Rhinological and Otological Society, Chicago, January 9, 1933.

Charles Goodman,² in 1917, reported a similar case in a woman aged 35 years. H. P. Mosher,³ in 1919, wrote about a young man, 26 years of age, who developed a postanginal sepsis with thrombosis of the internal jugular vein.

Mark Reuben,⁴ in a recent paper on this subject, referred to some earlier cases of postpharyngeal sepsis going as far back as Hippocrates and Galen. As a matter of fact, however, this form of sepsis with thrombophlebitis of the internal jugular vein has only recently received careful study.

There is no noteworthy study of postanginal sepsis in the German literature until 1921. At the first International Congress at Copenhagen, in 1928, pharyngeal sepsis was an important theme. This subject has received continued attention within recent years and series of case reports have been contributed from many sources.

In 1924 Fränkel⁵ showed that in the majority of cases of postanginal pyemia there is a thrombophlebitis in the small veins of the tonsils as well as in the facial vein extending into and involving the jugular.

The subject has been further studied by Uffenorde,⁸ Zange,¹⁶ Claus,¹⁰ Martens,¹⁷ Waldapfel,⁹ Kissling,¹⁴ Joel,¹⁸ Burchardt,¹⁹ Reye,²⁰ Lewin,²¹ Rössle,²² Wessely,²³ Melchior,²⁴ Keppler,²⁵ Riecke,²⁶ Artusi,¹⁵ Lenhartz,¹¹ Sternheimer¹² and C. Hirsch.²⁷ Extensive reviews have recently been contributed by E. Petzal⁶ and O. Voss.⁷

ANATOMY.

In a review of this nature it seems undesirable to enter into a detailed anatomic discussion of the structures of the pharynx. Though it must be mentioned that there are two important regions which may serve as the atria of infection. The retropharyngeal space lies anterior to the vertebral column and extends upward to the base of the skull and downwards towards the posterior mediastinum. It lies between the pharynx in front and the vertebral column behind. It is enclosed anteriorly and posteriorly by two layers of fascia. It invests the superior constrictor of the pharynx and is continued forward on the buccinator muscle. Laterally it blends with the sheaths of the great vessels.

The pharyngeal space is the connective tissue space which is separated medially from the tonsil by the constrictor muscles of the pharynx and the parapharyngeal fascia. The lateral boundary is formed by the internal pterygoid muscle, the ascending ramus of the lower jaw and the capsule of the parotid. The space extends upward to the base of the skull and downward along the esophagus and larynx into the posterior mediastinum. It is filled with connective tissue, fat, as well as important vessels and nerves. Here are found the carotid, the internal jugular, the ninth to twelfth cranial nerves and the sympathetic nerves. There is also a rich network of veins and numerous lymphatic glands.

An opening in the parotid fascia communicates this space with the parotid gland. Through an opening at the styloid process infection may spread from the pharyngeal space into the parotid gland, and from here infection may spread to the bony and cartilaginous ear.

PATHOGENESIS AND PATHOLOGY.

Fränkel first pointed out that the nature of postanginal sepsis was determined by the occurrence of a thrombophlebitis of the tonsillar veins. These thrombi extend progressively until a jugular thrombophlebitis is produced. Subsequent metastatic infections may occur in various parts of the body. Small thrombi become free and periodically enter the circulation, causing such symptoms as chills and fever. These small thrombi may produce infarcts in the lungs with associated pleurisy and empyema, or they may pass into the general circulation involving joints, muscles, kidneys, spleen and liver.

Intracranial complications may occur. Small thrombi may pass from the retrotonsillar veins through the pterygoid plexus into the cavernous sinus. Or the thrombi may originate in the internal jugular vein and be transmitted to sigmoid and transverse sinuses ending in purulent meningitis.

Uffenorde,⁸ who has written extensively on this subject, is not in full agreement with Fränkel's hematogenous theory as to the spread of infection. He differs from Fränkel by believing that a lymphangitis and a lymphadenitis are the primary processes, and

secondarily the purulent process extends to the veins causing a peri- and endo-phlebitis with an associated thrombosis.

Waldapfel supports Uffenorde's view and shows that the invasion into the jugular vein may be the result of lymphatic abscesses, which may occur not only in one but in numerous places along the course of the vein. Claus,¹⁰ on the basis of histologic investigation, thinks that the majority of cases of postanginal sepsis originate in abscesses which are found in the proximity of the tonsil, and that these pus collections spread deeper into the loose connective tissue of the pharynx and attach themselves to the walls of the veins, large and small, producing purulent peri- and endo-phlebitis.

Thus we have three views for the route of infection: the hematogenous, the lymphatic or by continuity through the tissue spaces. In whatever way the infection occurs the end result is the same. Thrombophlebitis and pyemia constitute the clinical aspect of the disease.

ETIOLOGY.

Postanginal sepsis is not due to a single organism. None of the bacteria which have been recovered from the septic processes have given rise to a characteristic clinical course. All seem to act about the same. Lenhartz¹¹ described one case of staphylococcal sepsis and Schottmüller also described several cases where staphylococci were found. It has been maintained that this group of organisms was especially likely to produce phlebitis and thrombophlebitis. Hemolytic streptococci and streptococcus viridans have been demonstrated in the pus and blood of some of these patients. The organisms are more readily recovered when a phlebitis or thrombophlebitis is present. It has been difficult to obtain positive cultures from the lymphnodes. Claus recommends that the blood be obtained from that point in the blood stream where the septic focus communicated with the general circulation. He thinks that this method may give positive results, whereas, the blood withdrawn from remote vessels will usually prove negative for organisms. The anaerobic organisms seem to be most frequently found in postanginal pyemia, and tend to produce thrombophlebitis. Thus the streptococcus putrificus (Schottmüller), an anaerobe, was found frequently. Consequently, the anaerobes, accord-

ing to the observation of numerous authors, may be said to preponderate as the exciting organism in postanginal sepsis. The aerobic infection is not considered to be as malignant, and indeed, most cases of postanginal sepsis that recovered have been thought to be due to the aerobic type of infection.

The disease usually follows a tonsillar infection, or sepsis may be preceded by a pharyngeal phlegmon, an intratonsillar abscess. There are a few cases in which the sepsis occurred during a scarlet fever attack, or after a tonsillectomy in which severe infections occurred. As a rule, the focus from which the sepsis develops is the retrotonsillar phlegmon. Whether a bacteremia or pyemia develops depends upon various factors difficult to determine. We speak of the immunity of the patient, the kind of organism which is found in the focus of infection, as well as its virulence. Whether there are other factors to be considered, it is impossible to state. It is known, however, that when phlebitis or thrombophlebitis occurs a threatening situation will ensue.

An idea of the relative occurrence of the disease, as well as the age of occurrence, may be illustrated by Uffenorde's analysis of 137 cases of postanginal sepsis. There were eighty-seven males and fifty females. Three were under 10 years of age, the youngest patient being 5 years old. While the low incidence reported in children of various ages must be accepted as correct in our present knowledge of the disease, nevertheless, more careful attention to clinical manifestations and more detailed autopsy records may show that our present estimate of the frequency of occurrence in young life has been underestimated.

CLINICAL COURSE.

It has already been stated that the majority of cases hitherto reported occur in young, healthy individuals. The greatest incidence is between 20 and 30 years. Localization on the left side seems to be more frequent than on the right. The pyemia may develop very shortly after the primary focal infection, or the general sepsis may be deferred as long as four weeks after the primary disease, though an analysis of all the cases shows that the average length of time is ten to fourteen days after the original infection. This constitutes a latent period, during which

the patient seems comparatively well. Waldapfel goes so far as to say that every tonsillitis in which the fever has not subsided in three days may be complicated by postanginal sepsis. If septic infection occurs after tonsillitis or pharyngeal phlegmon, one observes early painful swelling of the cervical gland on the affected side, located particularly at the angle of the jaw.

The occurrence of chills is of great importance, especially if they are observed after the angina has subsided (Sternheimer¹⁷). The occurrence of a chill indicates that organisms are gaining access to the circulation and that the inflammatory process is no longer circumscribed or walled off. Remittent fever may be associated with chills. In the severest forms of the disease a continuous high fever may be present without chills, extensive metastasis may occur, and death results after a short period. The patients present the general symptoms usual to a septic infection, such as pallor, subicteric hue, dry tongue, rapid pulse and rapid respiration, malaise, prostration and somnolence.

One would think that postanginal sepsis should occur in severe cases of scarlet fever. As has been suggested by Claus, the development of thrombi is proportioned to the severity of the infection. In the most virulent infections, thrombi do not occur. It must be considered, in a sense at least, that the formation of a thrombus is a defensive mechanism calculated to protect the individual against overwhelming blood stream invasion. In the most severe types of sepsis the bacteria may gain access to the blood stream in massive numbers, without producing phlebitis or thrombi. For this reason Friedemann and Elkeles¹⁸ find an explanation why thrombophlebitis does not occur in cases of foudroyant scarlet fever sepsis.

In some cases thrombi have been identified in the tonsillar vein, though in other instances only inflammatory changes in the walls of the vein have been found. Nevertheless, in either case they found that ligation of the jugular vein gave favorable results. These same authors also observed that during the second or late period of scarlet fever recurrent streptococcus infection with severe septic or pyemic manifestations led, as a rule, to a fatal termination.

COMPLICATIONS.

The most serious and most frequent complication is the formation of metastatic foci in the lungs (Kissling¹¹). Periarticular abscesses or septic arthritis are not infrequent. Abscesses in muscles, liver abscesses, suppurative kidney processes, and cavernous sinus infection, with the production of ocular symptoms and purulent meningitis, have been observed.

Paralysis of the hypoglossal nerve and the recurrent laryngeal nerve may result from abscess formation in the parapharyngeal space.

A few case reports of children suffering from postanginal sepsis will illustrate the clinical manifestations.

Case 1.—K. J., female, 8 years old (reported by O. Voss). Fourteen days before admission the child developed scarlet fever and was given convalescent serum. The temperature fell and the rash disappeared. Eight days later the child developed fever with tonsillitis and bilateral lymphadenitis. The attending pediatrician suspected peritonsillar abscess. The child complained of difficulty in swallowing. On the left side of the neck cervical glands could be palpated which were hard, painful to pressure and not fluctuating. The temperature was elevated, though there were no chills. A deep thrombophlebitis was suspected, an incision was made, some swollen lymphatic glands enveloped the sheath of the blood vessels. The jugular vein in its upper portion was thrombosed and cordlike. It was ligated and excised. Some thin pus exuded from an area posterior to the jugular, but upon further blunt dissection it was found that a large abscess was located between the carotid and the vertebral column. The left tonsil was subsequently removed and the child made an uneventful recovery.

Case 2 (Reported by Reye).—Female, age 18, developed an acute case of tonsillitis, with fever. In a very short time the cervical lymphnodes on the left side became intensely swollen and painful. She developed recurring chills, the fever was irregular, multiple abscesses occurred, which were localized in the supraclavicular space, the upper arm and in the articulations of the foot. These were incised. The patient died after a severe illness. The autopsy showed well marked thrombophlebitis of the left internal jugular vein with metastatic abscesses of the lungs and muscles.

Case 3 (Reported by Carlo Artusi).—Maria R., 3¼ years old. It is to be noted that the illness in this child began with a tonsillar infection. The crypts of the tonsils contained large numbers of organisms, and small abscesses occurred in the right tonsil. On admission to the hospital the patient showed all the symptoms of a generalized infection with metastases. Examination showed multiple abscesses, uveitis, keratomalacia, cardiac involvement, meningitis and chronic otitis media. The child died on the fifth day after admission.

The autopsy showed a thrombophlebitis of the jugular vein and of the left transverse sinus. There were multiple ulcers on the tongue, ulcerative endocarditis and a seropurulent pleurisy, and a confluent pneumonia.

There were also necrotic areas in the kidney. While it was not possible to determine whether the jugular thrombosis had originated from the middle ear or the pharynx, nevertheless, the otitis was chronic in character and the severe infection and thrombophlebitis followed shortly after the acute sore throat.

Case 4 (Reported by O. Voss).—A girl, 7 years old, had a severe sore throat, fourteen days previously, with high fever. Five days before she developed swollen, painful lymphnodes on the left side of the neck. High temperature was present but no chills. Both tonsils were red and swollen, though the one on the left side was more involved. Temperature 102, pulse 130. The temperature continued, as well as such general symptoms as prostration, anorexia. A vertical incision was made over the swelling at the left side of the neck, and a large mass was found which covered the sheath of the vessels, the walls of which were enormously indurated. The jugular vein was ligated. Continuing the dissection, a large abscess containing three or four tablespoons of pus was located behind the great vessels, and the abscess cavity was found to extend to the spinal column. At the same time the left tonsil was removed and two days later the right tonsil was enucleated because of the continued rise in temperature. The patient made an uneventful recovery.

PROGNOSIS.

The prognosis in postanginal sepsis is grave. Uffenorde collected 137 cases and only 40 recovered. These were cured by operation. In 17 cases reported by Reye, 12 died. Waldapfel lost 25 cases out of 43 who came under his care. Of these 25 fatal cases, 17 were operated upon and 8 were not. Claus reports 14 deaths in 28 cases.

In general it may be said, the earlier the purulent focus is detected and the contents evacuated, the more favorable the prognosis. Prompt surgical procedure, whether it be evacuating an abscess or ligating the jugular vein, will diminish the hazard of the disease and lower the mortality.

TREATMENT.

The treatment is for the most part surgical. If the septic focus can be located it should be drained. The difficulty is that the area of infection lies deeply imbedded and is difficult of access. In some instances abscesses in or about the tonsils may be incised. The tonsillar veins are sometimes filled with infected thrombi, and Zange advises that all of these small veins be ligated.

The parapharyngeal space may be the site of infection, and drainage of this small area may cause the greatest difficulty and

requires unusual technical skill. Where symptoms of general sepsis are present, as evidenced by chill and irregular fever, the jugular vein on the affected side should be ligated as early as possible, in order to prevent the formation of metastatic foci through the various tissues and organs of the body. All writers on the subject agree that early ligation of the jugular vein is the only logical treatment when the diagnosis of septic thrombophlebitis has been established.

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XXXIII.

THE EFFECTS OF CERTAIN DRUGS UPON LIVING
NASAL CILIATED EPITHELIUM.*

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The fact that normal ciliary activity persists in the presence of even the worst sinus infections demands a new conception of the mechanism of bacterial penetration in these parts. In the absence of experimental evidence, one can only surmise that bacteria penetrating at a single point can grow and spread indefinitely in the submucosa without incapacitating the overlying epithelium.

Careful scrutiny of more than fifty specimens examined promptly after operative removal from maxillary, ethmoidal and frontal sinuses strongly suggests that this is the case. If the penetration occurs at one point or even a few points, while the great majority of the surface remains intact, it would appear that the sinus contents play a relatively minor part in the progress of the disease and should be removed as a prophylactic rather than a therapeutic measure. How much the presence of this material may embarrass the subepithelial tissues in their struggle against the invaders is a problem. The fact remains that the cleansing mechanism is not destroyed and, in the plan of treatment, deserves every consideration and assistance. If in the (probably unsuccessful) attempt to reach the infection in the submucosa, one paralyzes or destroys the overlying cilia, he has disabled his best ally. It is important therefore to select with some care the drugs to be used, especially in the presence of acute infection.

Reports of observations of the effects of drugs upon ciliary activity are numerous.¹⁻¹⁰ For a resumé of this material the reader is referred to a recent article by Lierle and Moore.¹⁰

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The present study was suggested chiefly by the facilities at hand for observing the sinus lining of the rabbit *in situ* in the living animal. It is important for clinical purposes to employ undisturbed living mucosa, not only because of the circulation in the membrane, but chiefly because of the continued presence of the mucous blanket. In the excised specimens this is soon washed away and is, of course, not replaced. This applies equally to the killed animal. In the living animal the flow of mucus continues—is, in fact, sometimes stimulated, which alters the detrimental effects of drugs directly as they are soluble in the mucus. (cf. Table I as against Tables II and III.)

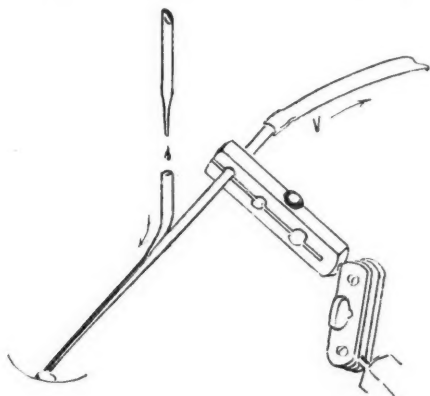
In this work each observation has been made upon a piece of fresh tissue not previously subjected to any other drug. Apparently, for reasons of economy, some observers have subjected a single strip of tissue to a succession of drugs, not only when the previous drugs have produced no apparent effect but even when "the activity of the cilia was below par before the [drug] was applied because of poor recovery from the previous application of a drug." Conclusions based upon the responses of cilia thus previously embarrassed, especially in an excised specimen or a dead animal, do not seem tenable.

The apparatus, which includes a microscope and a motion picture camera for recording ciliary activity and other mucosal functions such as the capillary circulation, has been previously described.¹¹ To this apparatus was adapted for the present purpose a double capillary tube for introducing and removing the solutions to be studied, under constant vision, through the microscope. The double capillary tube is made by crossing two glass tubes and heating them at their junction in a Bunsen flame. When they become fused they are drawn out to a capillary. If the flame is not too hot, the two lumina remain discrete throughout their length, no matter how finely drawn. The result is two Y-tubes with double capillaries for stems. The branches of the Y are connected with rubber tubing, one to the drug supply, the other to a constant suction pump. (See Figure.) By this means, the fluid under study is constantly supplied to a very limited area of mucosa, and at the same time is being withdrawn at a rate which prevents flooding the sinus, embarrassing the rabbit's respiration,

or producing any remote effect on the animal. The capillary tips are seen in the field of the microscope.

For the sake of comparison and accuracy, three parallel series of experiments were done: the first upon the living rabbit membrane undisturbed in the sinus; the second upon the human material removed from sinuses at operation and kept in physiologic sodium chloride solution or in Ringer's solution; and third, upon extirpated rabbit membrane kept and examined in the same manner as the human material. It is felt that deductions from these three series may reasonably be applied to living human membranes.

Previous experiments¹² having shown that the cilia were more active at thirty degrees and below than at thirty-seven, and that



low temperatures did not incapacitate them, the routine care of removed tissues was as follows: At operation the tissue was transferred directly from the patient to Ringer's solution (in a few cases Tyrode's) at room temperature. Portions not used for study remained in these solutions as controls. When it was necessary to preserve them overnight, they were left in a refrigerator (circa 5° C.) and examined the following day at room temperature. Under these conditions the cilia remained active through the second, and at times even the third day.

The routine plan followed in the rabbit experiments was essentially that described for the observation and photography of

Wave motion and heat and cold effects,¹¹ with the addition of the capillary tube described above. A cooling chamber was employed between the condensing lens of the vertical illuminator and the source of illumination and the light was shut off between observations to avoid heating.

Two types of application were made: In the first instance, the drug was allowed to act upon the surface for a restricted time in order to simulate clinical conditions. After removal, in the living rabbit, nothing further was done, the circulation and secretion being depended upon to free the membrane of the drug. The extirpated specimens were washed with Ringer's solution from the beakers containing the controls in order to maintain similar conditions. In the second type of application, the drug was continuously applied (the extirpated specimens being immersed in it) until motion ceased. Deviations from these two plans are indicated in the tables.

The results of experiments thus far completed are as follows:*

Sodium Chloride Solutions.—Cilia of both man and rabbit remain active for long periods in .9 per cent sodium chloride at room temperatures between 25 and 30 degrees. Some of the controls were beating vigorously at the end of six hours.

As the sodium chloride solution is increasingly concentrated, areas of cilia cease beating. The effect is unlike that of cold, under which a general slowing occurs. At a concentration of 4 to 4.5 per cent all activity ceases.

If the membrane is washed within a few minutes with distilled water and again immersed in .9 per cent sodium chloride solution, activity soon returns which appears in nowise different from that of the controls.

If the concentration of the solution is reduced, the sharp outlines of the cilia are gradually lost and the surface becomes cloudy. Even groups of cilia can no longer be distinguished, and all motion ceases at .2 to .3 per cent concentration. Addition of sodium

*For the sake of completeness this list includes some observations previously reported. Proetz—Transactions of Royal Society of Medicine, Section of Laryngology, 1934, and Journal of Laryngology and Otology, in press.

chloride in any concentration now fails to restore motion. The cilia have been permanently disabled.

Liquid Petrolatum (Light, Sp. Gr. 880).—Cilia act indefinitely when the specimen is immersed in this medium or when the living sinus is flooded with it. One has the impression that streaming, however, is feeble or absent. Stray erythrocytes on the surface show no tendency to move along as they so definitely do in mucus. If, after twenty minutes' immersion in this oil, the surface is bathed in 10 per cent cocain hydrochloride solution, action ceases instantaneously, suggesting that the oil was not in actual contact with the cilia at all, but separated from it by mucus.

Ephedrin Sulphate.—Three per cent. Extirpated membranes show ciliary activity for fifteen minutes or more after immersion in 3 per cent ephedrin solutions. After returning to Ringer's solution, some areas return to normal activity. The living mucosa in the rabbit seems unaffected by this solution.

Two per cent in physiologic sodium chloride solution. Five minute applications of this concentration followed by Ringer's solution produce no demonstrable changes. Constant immersion for as long as two hours sometimes failed to stop activity.

One-half per cent. In the rabbit, activity in this solution which is recommended for treatment by displacement, differed in no way from the controls, and extirpated specimens remained active from twenty-seven minutes to one hour and thirty-five minutes.

The "plain" ephedrin in oil averaged nineteen minutes.

Cocain Hydrochlorid.—Ten per cent solution stopped the action of most of the specimens immediately. The longest survival was two minutes. Attempts at resuscitation with Ringer's solution met with occasional success. In the rabbit, all motion ceased in three minutes. Six minutes of washing in Ringer's solution revived it in a few areas.

Five per cent. In the extirpated specimens, motion stopped in from one to three minutes. Attempts to revive it failed. In the rabbit, the speed of cilia was immediately slowed to half, and remained so for more than two hours.

Two and one-half per cent. In most cases, very little effect was noted from this solution. Continuous application for one hour was required to stop the cilia. The rabbit's mucosa showed blanching, but no change in ciliary motion.

Epinephrin.—1/1000 caused immediate cessation of beat, which in the large majority of instances could not be re-established. In one case, motion having stopped in a few seconds, application of Ringer's solution for forty-five seconds succeeded in restoring it, after which it continued for one hour and thirty minutes. The control in this case beat for six hours. In the rabbit, ten seconds sufficed to stop action, which could not be resuscitated.

1/5000. Activity in this solution persisted for twenty-five minutes, against controls which continued for two to four hours. In the rabbit, two applications of one-half minute each, with an interval of three minutes, slowed the beat to three per second.

1/10,000. After five minutes' contact with this solution, activity persisted for upward of two hours. Complete cessation occurred in twenty minutes; resuscitation was possible. In the rabbit, four one-half minute applications with intervals of three minutes produced a slowing to six beats per second in some areas but not in others.

Camphor.—One per cent in liquid petrolatum. This drug had no apparent effect upon the living membrane. A strip of excised membrane showed normal activity at the end of forty-three minutes. What has been said regarding the failure of liquid petrolatum to "wet" the membranes applies equally to the drugs here recorded which were dissolved in it.

Menthol.—One per cent in liquid petrolatum. This drug had no apparent effect upon the living membrane. A strip of excised tissue immersed in it showed activity one hour and twenty-four minutes later.

Thymol.—One per cent in liquid petrolatum. This drug produced some irritation of the membrane immediately and slowed the activity of the cilia to three or four per second, stopping them in some areas altogether. A strip of excised tissue immersed in it showed complete cessation of ciliary activity in six minutes.

Mild Silver Protein (Argyrol).—Ten per cent produced no demonstrable effect upon the living membrane, although both here and in the excised strip there was mechanical interference with streaming, caused by the clumping of the drug over the surface. Strips immersed in it beat from thirteen to fifty-four minutes.

Dibrom-oxymercuri-fluorescein (Mercurochrome).—Two per cent aqueous solution. This drug produced some slowing of the cilia for an indefinite period in the living sinus after applications of two and four minutes respectively. Excised strips ceased moving from eight to seventeen minutes after immersion.

Sodium Ethyl-mercurithiosalicylate (Merthiolate).—1/1000. This solution applied to the living membrane for two minutes produced a pronounced slowing in the ciliary beat. Flushing with Ringer's solution for two minutes did not accelerate it again. A second application for two minutes caused it to stop entirely, nor could it be resuscitated with Ringer's solution.

1/10,000. In this strength, a two-minute application also caused some slowing, although less appreciable than with the stronger solution. Ringer's restored the rate practically to normal, but a subsequent application for four minutes stopped all motion and no resuscitation occurred. Excised strips were not subjected to this drug.

A single rabbit was tested with streptolysate. After two minutes the cilia were beating at approximately the normal rate. A second application, this time for four minutes, resulted in a pronounced slowing. A repetition of the experiment in the opposite sinus gave approximately the same result. The particular lysate employed was preserved in 1/5000 merthiolate.

It should be pointed out that these experiments deal only with the rate and persistence of the ciliary beat and are not to be regarded alone as an index of therapeutic value.

COMMENT.

In attempting to apply these findings to clinical requirements, one must guard against overemphasizing their importance. Still

it is logical to select for a given purpose a drug which will upset as little as possible the normal function of the part.

On this score, one should recommend ephedrin in preference to cocain or epinephrin in all cases in which its action will suffice. So far as its effect on cilia is concerned, it may be used in any strength up to 3 per cent with impunity.

If cocain is required for anesthesia, or epinephrin for ischemia, it would appear that the weakest effective solution should be chosen to insure ciliary activity immediately after operation. None of the turbinated bones examined after operations under cocain anesthesia with epinephrin showed any ciliary activity, although the adjacent sinus linings invariably did so. The fact that normal appearing cilia were present indicates that they were paralyzed by the preliminary cocain and epinephrin.

General anesthesia with sodium amytal or morphin and scopolamine has apparently no effect upon the ciliary beat, which resembles in all respects that seen in rabbits killed by air injection or spinal section.

Oily mixtures are to be avoided where ciliary streaming still functions, because they interfere not with the ciliary beat, but with its effectiveness by lying upon the mucous blanket and being propelled with great difficulty by it.

Colloidal solutions having a tendency to "clog" the streams of mucus are to be avoided. Since the infectious process is beneath the epithelium, it is doubtful whether any antiseptic value which they may possess can compensate for their mechanical disadvantages.

If one persist in the use of aromatics despite the fact that they are inert or perhaps a little irritating, let him at least confine himself to camphor and menthol and avoid thymol.

The most striking impression one receives in the course of this work, as on other occasions, is once more the extreme hardihood of the cilia and their persistence in functioning. The only drugs in the above list which promptly stopped the action altogether are strong solutions of cocain and of epinephrin. Other drugs which stopped or slowed them in the extirpated strips were much less potent in the living membrane, constantly bathed in circulating body fluids.

Temperature changes, short of actual heat coagulation, while they temporarily vary the rate, in no way harm the cilia.

As for treatment by displacement or other injection, after which the fluid is intended to remain for some hours in the sinus, one-half per cent solution of ephedrin in physiologic sodium chloride still appears to be the safest solution.

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SERIES I.

MEMBRANES IN THE LIVING RABBIT SINUS.

Exp. No.	Drug	Duration of Application	Duration of Activity	Resuscitated	Comment
R 1	Cocain HCL 2½%	3 m.	indef.	.....	Some blanching
R 1a	Cocain HCL 2½%	3 m.	indef.	.....	Some blanching
R 5	Cocain HCL 2½%	1 m.	indef.	.....	Interval of 3 min. between applications
R 5a	Cocain HCL 2½%	1 m.	indef.	.....
R 5b	Cocain HCL 2½%	1 m.	indef.	.....
R 21	Cocain HCL 2½%	3 m.	indef.	.....
R 22	Cocain HCL 2½%	3 m.	indef.	.....	.....
R 2	Cocain HCL 5%	3 m.	slowed	yes	Ringer's
R 2a	Cocain HCL 5%	3 m.	slowed	yes	Ringer's
R 21a	Cocain HCL 5%	5 m.	slowed	yes	.....
R 22a	Cocain HCL 5%	3 m.	slowed	yes	Ringer's 5 m.
R 3	Cocain HCL 10%	3 m.	3 m.	6 m.	Few areas
R 6	Cocain HCL 10%	1 m.	1 m.	slow	Very few
R 21b	Cocain HCL 10%	50 s.	50 s.	no	Ringer's
R 7	Epinephrin 1-10M	.5 m.	slowed	yes	Ringer's
R 7a	Epinephrin 1-10M	.5 m.	slowed	yes	Ringer's
R 7b	Epinephrin 1-10M	.5 m.	slowed	yes	Ringer's
R 7c	Epinephrin 1-10M	.5 m.	slowed	yes	Ringer's
R 23	Epinephrin 1-10M	6 m.	slowed	no	Ringer's
R 24	Epinephrin 1-10M	10 m.	indef.	.....	.....
R 8	Epinephrin 1-5M	.5 m.	very slow	?	3 per sec.
R 8a	Epinephrin 1-5M	.5 m.	very slow	no	3— per sec.
R 23a	Epinephrin 1-5M	.5 m.	very slow	yes	Ringer's 10 m.
R 9	Epinephrin 1-1M	10 sec.	10 sec.—	no	Stopped imme- diately
R 12	Epinephrin 1-1M	10 sec.	10 sec.—	few	2 to sec. after 24 m.
R 23b	Epinephrin 1-1M	40 sec.	40 sec.	no	.....
R 24a	Epinephrin 1-1M	30 sec.	30 sec.	no	.....
R 10	Ephedrin sulphate 2% N/Sal.	4 m.	indef.	.....	.....
R 10a	Ephedrin sulphate 2% N/Sal.	4 m.	indef.	.....	.....
R 11	Ephedrin sulphate 3%	1 m.	indef.	.....	Rate remained 8-10 per s.
R 11a	Ephedrin sulphate 3%	1 m.	indef.	.....
R 11b	Ephedrin sulphate 3%	indef.	indef.	.....
R 4	Argyrol 10%	1 m.	indef.	most areas	Some physical interference noted
R 4a	Argyrol 10%	2 m.	slowed 2 m.	most areas	
R 4b	Argyrol 10%	5 m.	slowed 2 m.	most areas	
R 22b	Argyrol 10%	20 m.	indef.	q. 2 m.	Ringer's
R 15	Merthiolate 1-1M	2 m.	slowed 2 m.	no	Ringer's
R 15a	Merthiolate 1-1M	2 m.	stopped 4 m	no	Ringer's
R 16	Merthiolate 1-1M	2 m.	stopped 4 m	no	Ringer's
R 16a	Merthiolate 1-10M	2 m.	slowed 2 m.	yes	Ringer's
R 16b	Merthiolate 1-10M	4 m.	stopped 4 m	no	Ringer's
R 15	Mercurochrome 2%	2 m.	slowed 2 m.	no	Ringer's
R 15a	Mercurochrome 2%	4 m.	slowed 2 m.	no	Ringer's
R 16	Liq. Petrolatum	indef.	indef.	.....	.....
R 17	Epheclin in oil 1%	indef.	indef.	.....	.....
R 18	Camphor in oil 1%	indef.	indef.	.....	.....
R 19	Thymol in oil 1%	10 m.	very slow 10 m.	slightly	.....
R 20	Menthol in oil 1%	indef.	indef.	.....	.....

SERIES II.
EXTIRPATED MEMBRANES FROM RABBITS' SINUSES.

Exp.	Drug	Cilia stopped after immersion of
RE 1	Dibrom-oxymercuri-fluorescein (Mercurochrome) 2%.....	8 min.
RE 2	Dibrom-oxymercuri-fluorescein (Mercurochrome) 2%.....	17 min.
RE 3	Dibrom-oxymercuri-fluorescein (Mercurochrome) 2%.....	17 min.
RE 4	Dibrom-oxymercuri-fluorescein (Mercurochrome) 2%.....	18 min.
RE 5	Dibrom-oxymercuri-fluorescein (Mercurochrome) 2%.....	14 min.
RE 6	Mild colloidal silver (Argyrol) 10%.....	54 min.
RE 7	Mild colloidal silver (Argyrol) 10%.....	13 min.
RE 8	Mild colloidal silver (Argyrol) 10%.....	27 min.
RE 9	Mild colloidal silver (Argyrol) 10%.....	39 min.
RE 10	Mild colloidal silver (Argyrol) 10%.....	48 min.
RE 11	Cocain hydrochlorid 10%.....	2 min.
RE 12	Cocain hydrochlorid 10%.....	2 min.
RE 13	Cocain hydrochlorid 10%.....	1/4 min.
RE 14	Cocain hydrochlorid 10%.....	1/4 min.
RE 15	Cocain hydrochlorid 10%.....	1 1/2 min.
RE 16	Liquid Petrolatum.....	30 min. +
RE 17	Liquid Petrolatum.....	27 hrs.
RE 18	Liquid Petrolatum.....	1 hr. 21 m. +
RE 19	Ephedrin in oil 1%.....	17 min.
RE 20	Ephedrin in oil 1%.....	20 min.
RE 21	Ephedrin in oil 1%.....	15 min.
RE 22	Ephedrin in oil 1%.....	25 min.
RE 23	Ephedrin in oil 1%.....	18 min.
RE 24	Ephedrin in N/Saline 1/2%.....	27 min. +
RE 25	Ephedrin in N/Saline 1/2%.....	38 min.
RE 26	Ephedrin in N/Saline 1/2%.....	1 hr.
RE 27	Ephedrin in N/Saline 1/2%.....	1 hr. 25 m.
RE 28	Camphor 1% in liq. petrol.....	43 min. +
RE 29	Thymol 1% in liq. petrol.....	6 min.
RE 30	Menthol 1% in liq. petrol.....	1 hr. 24 m.

SERIES III.

EXTIRPATED HUMAN MEMBRANES.*

Patient, No. Sinus†	Drug, Temp., etc.	Interval after Excision	Duration of Activity	Control
1. HH10M	Ephedrin 3%	?	Indefinite.	Indef.
2. MK16M	Ephedrin 3%	?	Indefinite.	Indef.
3. RM43M	Ephedrin 3%	?	30 minutes.	—
4. MS24M	Ephedrin 3%	1 hour	65 m. including moistening with Ringer's. Ephedrin on 5 m.	1 h. 50 min.
5. WN47M	Ephedrin 3%	½ hour	15 m. with resuscitation.	2 h. 50 m.
6. WN47M	Ephedrin 3%	½ hour	1 h. 15 m. saline and ephedrin alternately.	2 h. 50 m.
7. JO45M	Ephedrin 3%	½ hour	2 h. 10 m. saline and ephedrin alternately.	2 h. 45 m. +
8. NS39M	Ephedrin 3%	10 min.	Indefinite.	2 h. +
9. LL23M	Ephedrin 2%	2 hours	Indefinite.	2 h. +
10. BD32M	Ephedrin 2%	40 min.	1 h. 45 m. + saline and ephedrin alternately.	1 h. 45 m. +
11. S30M	Ephedrin 2%	7 min.	2 h. 20 m. + ephedrin and Ringer's alter.	3 h. +
12. HB33M	Cocain 2½%	—	45 m. + Ringer's added when drying.	45 m. +
13. GM32M	Cocain 2½%	20 min.	6 h. 10 m. + Ringer's added when drying.	6 h. 10 m. +
14. GM32M	Ephedrin 2%	1 hour	5 h. + Ringer's added when drying.	6 h. 10 m. +
15. C2E	Cocain 2½%	½ hour	3½ hours.	Dried
16. C2E	Ephedrin 2%	½ hour	3½ hours.	Dried
17. EW46M	—	—	—	Cilia moving in Ringer's. No cilia seen
18. OS25T‡	—	—	—	—
19. LW41M	Argyrol 10%	10 min.	5 minutes. +	5 m. +
20. RI59E	Cocain 5%	20 min.	10 minutes.	1 h. 20 m. +
21. RI59E	Ephedrin in oil	20 min.	1 hour 20 minutes. +	1 h. 20 m. +
22. RI59E	Albolene	20 min.	45 minutes. +	1 h. 20 m. +
23. JW46M	Epinephrin 1-1M	20 min.	4 minutes.	—
24. AS28M	Albolene	20 min.	1 hour 50 minutes. +	1 h. 50 m. +
25. AS28M	Cocain 5%	20 min.	1 h. 30 m. + 5 m. resuscitated with Ringer's.	1 h. 50 m. +
26. AS28M	Ephedrin in oil 1%	20 min.	1 h. 23 m. +	1 h. 50 m. +
27. CH63M	Argyrol 5%	20 min.	2 h. + (dried)	6 h. +
28. AS28M	Epinephrin 1-10M	20 min.	45 m. + (lost field)	6 h. +
29. AS28M	Epinephrin 1-1M	20 min.	Stopped within few sec. 45 sec. later Ringer's added—ran for 1½ h. +	6 h. +
30. HJ7M	Epinephrin 1-1M	45 min.	Cilia stopped immediately.	3½ h. +
31. HJ7M	Epinephrin 1-1M	50 min.	15 sec.; revived with Ringer's.	3½ h. +
32. HJ7M	Epinephrin 1-10M	55 min.	2 h. 50 m. + 20 m. after epinephrin. Ringer's added.	3½ h. +
33. HJ7M	Cocain 5%	60 min.	2 h. 30 m. + One application of Ringer's added when drying.	3½ h. +
34. AN41M	Refrigerator 5° C	35 min.	5 h; stopped when examined at 7 h.	—

*The experiments in this table are recorded in the order in which they were performed, rather than in groups pertaining to the several drugs, so that comparison may readily be made of the tissues of a given individual and their responses.

† M, maxillary; E, ethmoid; T, middle turbinate body which had been subjected to cocain 10% before operation.

SERIES III.—Continued.
EXTIRPATED HUMAN MEMBRANES.

Patient, No.	Age, Sex	Drug, Temp., etc.	Interval after Excision	Duration of Activity	Control
35.	BC15M	Refrigerator 5° C	30 min.	41 h.+ slightly.	.....
36.	BC15M	Incubator 36° C	30 min.	41 h. 10 m.+ slowly.	.....
37.	BC15M	Room temp. 28° C	.....	18 h.+ beating briskly.	.....
38.	BC15M	Epinephrin 1-10M	17 h. 37 m.	1. 50 m. resuscitated. 2. 5 m. resuscitated. 3. 5 m. not resuscitated.	41 h. 10 m.+
39.	BC15M	Epinephrin 1-10M	17 h. 59 m.	1. Stopped immediately —resuscitated. 2. Stopped immediately —not resuscitated.	41 h. 10 m.+
40.	EH30M	Epinephrin 1-10M	19 min.	1. Stopped within 1 m. —resuscitated. 2. Stopped immediately —not resuscitated.	2 h. 52 m.+
41.	EH30M	Cocain 5%	1 h. 57 m.	3 m. stopped.	2 h. 52 m.+
42.	EH30M	Ephedrin 3%	2 h. 19 m.	7 m. completely stopped, few resuscitated. 14 m. completely stopped.	2 h. 52 m.+
43.	BC15M	Cocain 2½%	15 min.	1 h. all stopped except few. Not resuscitated.	4 h. 25 m.+
44.	BC15M	Cocain 5%	28 min.	1. 1 m. all movement practically stopped. 2. Stopped immediately.	4 h. 25 m.+
45.	BC15M	Ephedrin 3%	3 min.	16 m. very few moving— resuscitated ½ h.+	4 h. 25 m.+
46.	R?M	Cocain 2½%	35 min.	7 minutes.	5 h. 30 m.+
47.	R?M	Ephedrin 2%	4 h. 37 m.	9 m. (most stopped); 1 m. slower.	5 h. 30 m.+
48.	R?M	Epinephrin 1-1M	1 h. 24 m.	30 sec. stopped immedi- ately.	5 h. 30 m.+
49.	R?M	Ephedrin 3%	1 h. 27 m.	1. 17 m. most have stopped. 2. Stopped immediately. 3. 5 m. stopped — could not resuscitate.	5 h. 30 m.+ 2 h. 15 m. few cilia moving.
50.	D?M	.....	.....	.....	.....
51.	R?M	Epinephrin 1-5M	18 min.	28 m. few still going. 36 m.+	4 h. 40 m.+
52.	R?M	Ephedrin 2%	58 min.	52 m.+ 60 m. stopped.	7 h. 40 m.+
53.	R?M	Cocain 5%	1 h. 45 m.	10 m. stopped—resusci- tated.	7 h. 40 m.+
54.	R?M	Cocain 5%	1 h. 13 m.	3 m. stopped—not resusci- tated.	7 h. 40 m.+
55.	R?M	Heat and cold	6 hours	11½° C stopped—resusci- tated. 45° C stopped—not resusci- tated.	7 h. 40 m.+ 1 h. 10 m.+
56.	FE?M	Cocain 2½%	30 min.	14 m. practically stopped. 2 m. few still moving.	1 h. 10 m.+
57.	FE?M	Cocain 5%	37 min.	Stopped immediately, not resuscitated.	1 h. 10 m.+
58.	SR?E	Cocain 5%	1 h. 21 m.	Within 1 m. completely stopped.	2 hours+ 2 hours+
59.	SR?E	Epinephrin 1-5M	1 h. 26 m.	29 m. (almost stopped).	2 hours+
60.	SM?M	Cocain 2½%	29 min.	1½ m. almost all stopped.	None
61.	SM?M	Cocain 5%	37 min.	Stopped immediately — not resuscitated.	None
62.	SM?M	Epinephrin 1-5M	51 min.	10 m. all stopped except few.	None

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PRIMARY CARCINOMA OF EXTERNAL AUDITORY CANAL.*

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ST. LOUIS.

Very meager references to primary carcinoma of external auditory canal will be found in texts of surgery and otology. Such references as are found are mere mentions of the condition, with very little discussion of symptomatology, diagnosis or treatment. Carcinoma of the external auditory canal, with or without involvement of the middle ear and mastoid, must be sharply differentiated from carcinoma of the auricle. The term "carcinoma of the ear" is generally understood to designate the latter condition, which is by no means rare and is rather readily diagnosed. One of the objects of this paper is to emphasize the difference between primary carcinoma of the external auditory canal and diseases of the auricle and middle ear. For these reasons a study of the available literature was made. One of the early discussions of the subject is by Kummel,¹ who described the condition in 1912. He refers to some earlier presentations and outlines a brief comprehensive study of the symptoms, differentiation, diagnosis and prognosis.

In describing malignancy of the external auditory canal, Kummel cites the difficulty in early diagnosis, especially in differentiating it from an auditory canal eczema, chronic middle ear suppuration with cholesteatoma and sarcoma of the auditory canal. He places marked emphasis on pain as an early symptom, and on the relatively early occurrence of facial paralysis and labyrinthian involvement. He notes the rarity of lymph node metastasis and the common occurrence of destruction, which may extend deeply into the neck. The parotid gland, mandible and carotid artery may be completely destroyed. It is interesting to note that the

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carotid artery may be lying free in a necrotic carcinomatous area, and may be completely obliterated without the occurrence of hemorrhage. Patients commonly die from marasmus and rarely from brain or lung complications. The tumor may invade the base of the skull, yet brain abscess and meningitis are extremely rare. He points out that deafness may be an early symptom and may be of the nerve or internal ear type.

From our study of the literature it became apparent that references to the subject occur with increasing frequency since 1912. Robinson,² in 1931, cites nineteen cases of primary carcinoma of the ear and external auditory canal. Barnes,³ in 1930, reports ten cases of cancer of canal and middle ear. C. E. West (quoted by Barnes) said all cases begin in the external auditory canal even when the middle ear is involved. J. S. Fraser⁴ reports three cases of malignancy of the canal in 646 private cases of external disease of the ear (.464 per cent). The records of the Royal Infirmary show thirteen cases out of 6,605 external ear conditions (.197 per cent). Fraser reports eleven cases that he has seen both in private and clinic practice. Individual case reports may be found with increasing frequency in literature of recent years.

It may thus be inferred that the diagnosis of the condition is made more readily than prior to Kummel's report in 1912. Biopsy with histologic study no doubt has played a big rôle in making the diagnosis possible. However, in our opinion, insufficient emphasis has as yet been placed on the great importance of obtaining an early diagnosis. It is evident from a study of the literature that only by early recognition and adequate treatment is there any possibility of a successful outcome of such cases. Kummel, in his article, does not stress early diagnosis, because in his time all cases probably terminated fatally. Robinson, Barnes, Fraser, Chubb and Ormerford⁵ report cases alive and well as long as eleven years following adequate treatment.

From our perusal of the literature and from the early history of our own case, the symptom which should be most emphasized is pain. We believe that severe, excruciating pain which persists for more than a week in obscure external auditory canal lesions should bring to mind the possibility of malignancy. The cause of this severe and uncontrollable pain, puzzling because it is not a usual

early symptom of malignancy in other parts of the body, is a moot question. Some authors attribute it to the mixed infection which occurs early. Others attribute it to early involvement of periosteum or perichondrium. We cannot too heavily stress this symptom of pain. It is unlike the pain of acute otitis media (chronic otitis media is usually painless), or the pain of external otitis which usually subsides in a few days. The pain in carcinoma of the auditory canal comes on early, is unremitting and requires large doses of opiates to control, even in the early stages.

A common site for the lesion is the anterior inferior part of the external auditory canal. It may be mistaken at first for an acute external otitis, or eczema of the canal, but which fails to respond to routine treatment. Soon the skin layer is broken through and a polypoid change takes place. This may or may not be accompanied by a discharge. The polypoid tissue is made up of granulations. The usual routine treatment would include removal of these granulations with a curette. At this point we wish to emphasize that in every obscure case all growths removed from the ear canal should be sent to the laboratory for histologic study, as this may be the earliest possible moment to make the diagnosis. Attention should also be paid to the base of the granulation to ascertain if denuded bone is felt. This also is an early diagnostic sign. If the diagnosis can be made at this early stage, the prognosis is quite favorable under adequate treatment. Failing diagnosis at this early stage, the tumor may rapidly invade and destroy contiguous regions and make the prognosis practically hopeless.

Facial paralysis is mentioned by Barnes as being a very early symptom. He cites two cases where paralysis was coincident with pain at the very onset. Kummel mentions that the pain may simulate a typical trigeminal neuralgia. It is conceivable that this type of pain might occur in a case with coincident facial paralysis, thus rendering early diagnosis more difficult. Facial nerve paralysis is probably due to pressure on or involvement of the nerve trunk as it enters the parotid gland.

While there is little or no tendency to bleed in the extensive destroyed areas of the new growth (Kummel), it is to be noted that the granulations found early in the disease, before destruction has set in, have a marked tendency to bleed (Barnes).

Chronic suppurative otitis media may simulate cancer of the external canal, which has involved the middle ear and mastoid. It should be kept in mind that intractable pain out of keeping with the objective picture should make us think of the possibility of malignancy. It is only by being on one's guard and having the possible diagnosis in mind that we can hope to be able to do anything to save the life of our patient. When surgery is resorted to for such an "atypical mastoiditis," the mastoid and surrounding soft tissues may be sufficiently suspicious to warrant a biopsy. This is cited as being the more frequent time of diagnosis. To save the patient, in most cases, diagnosis must be made before this amount of involvement has occurred.

Treatment of carcinoma of the external auditory canal, as discussed in the literature, is no different from treatment of carcinoma elsewhere in the body. The knife, cautery, diathermy, application of radium in the form of actual element with standardized screening, insertion of radon implants and deep X-ray therapy, have all been used alone and in various combinations. It is also emphasized in the literature that the probability of recovery depends more on the early institution of any of the above methods than on the methods themselves. Cases reported as cured are those which were put under adequate therapy while the lesion was localized to the external auditory canal. The importance of early diagnosis is again emphasized.

There were a number of observations to be made in our own case which corroborate findings reported in the literature, as well as some which are at variance with reported data. Our patient was a white female, aged 49, referred to one of us (M. F.) by her family physician on June 8, 1932. The history given at that time was that the patient had had a discharge from the right ear since December, 1931, which did not yield to her physician's treatment. The condition was reported as starting with a small, granulating area on the floor of the canal just inside the external meatus. At the onset the eardrum was definitely reported as being normal. At this time the patient complained of marked pain in her ear, which was constant and not relieved by any treatment. The report from her physician further stated that the granulating area on the floor grew larger and larger, eventually hiding the drum membrane from view. There was a copious foul purulent secretion. When seen by one of us (M. F.) on June 8, 1932, the right ear canal was filled with granulations bathed in a foul smelling exudate. The patient's chief complaint was agonizing pain. It was noted that the pain was out of keeping with the objective findings in a patient who was not of the neurotic type. The granulations were com-

pletely curetted out amid copious hemorrhage. Denuded bone was felt with the curette along the floor of the canal. The drum membrane was completely destroyed and the middle ear cavity was filled with foul smelling pus. Opiates were given in addition to the local insufflation of orthoform powder in an attempt to control the pain. The patient was hospitalized on June 20, 1932. Radiographs of mastoids were made and showed a peculiar picture which was reported by the roentgenologist (Dr. Schnobelin) as osteomyelitis of skull bone surrounding mastoid area and mastoiditis. On June 21, 1932, a radical mastoidectomy was performed. At operation it was found that the soft tissues, including the floor of the canal and extending to the anterior surface of the mastoid, were necrotic and friable. The mastoid itself was sclerotic. No pathology other than the ivory-like consistency of the bone was found in the mastoid. Sections

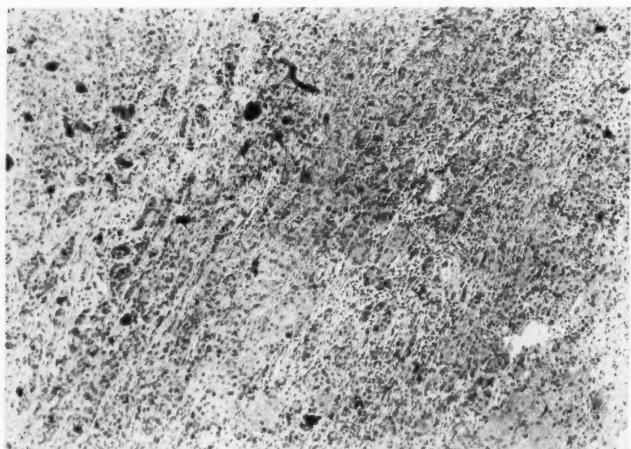


Fig. 1. Photomicrograph showing quite typical areas of carcinoma. More than 25 per cent of the cells making up the tissue are differentiated.

from the soft friable area were sent to the laboratory for histological examination. Because of the destruction of tissue it was impossible to close the wound with the usual Panse flap. The post-auricular wound was sutured and iodoform gauze packed into the canal.

The histological diagnosis made by Dr. Sam H. Gray was squamous cell carcinoma. According to the histological grading of Broders, it was a Grade III carcinoma (Fig. 1).

Deep X-ray therapy was instituted at once and two four-minute and two five-minute periods during July 9, 1932, to July 13, 1932, and three five-minute and one four-minute period during August 2, 1932, to August 5, 1932, inclusive. The setup was as follows: Port 20; K. V. 200; M. A. 30; distance 50 cm.; Filters 0.5 mm. copper plus 1 mm. aluminum.

The condition steadily advanced with no abatement of the excruciating pain. The operated area underwent widespread necrosis; the accompanying discharge being of a very foul character. About August 5, 1932, a swelling, which constantly increased in size, was noted in the jugulodigastric group of lymph nodes. The nodes were soft and the overlying skin was intensely reddened, doughy and indolent. The attachments of the auricle were rapidly being destroyed. Gross malignancy could be noted in the depths of the wound and in the subcutaneous tissue of the contiguous margins. There was a constantly increasing lack of appetite and loss of weight throughout this period. Radium treatment was instituted on September 28, 1932, when 150 mgms. of radium screened with 1 mm. silver and 1 mm. rubber were placed in the defect and allowed to remain for eight hours (L. H. J.). (1200 mgm. hours.) On November 1, 1932, there was a definite facial paralysis of all three branches on the right side. No other cranial nerve involvement was noted. The hearing remained stationary at four feet for whispered voice throughout the whole course of the disease. Trismus was noted on January 1, 1933. There was a progressive decline in the patient's general condition, without any abatement of severe pain at any time during the nine months that this patient lived from the time we first saw her. As much as 10 grains of morphin was used in a day to control the pain. On January 20, 1933, the remains of the auricle were removed by actual cautery and radium in the form of needles was inserted into a mass of malignant tissue which had extended forward and downward along the ramus of the mandible (1000 Mghrs.) (L. H. J.) Some of the temporal bone was seen denuded of muscle and fat, and the styloid process was lying free in the depths of the large cavity. The middle ear and mastoid remained relatively unchanged since the time of operation. It is interesting to note that despite the tremendous amount of tissue destruction there was never any hemorrhage from the wound. The carotid artery and jugular vein were completely destroyed without any primary or secondary hemorrhage. These large vessels were apparently occluded and slowly destroyed by the low-grade inflammatory process and by the contiguous progressive growth of the tumor. Despite the fact that these large vessels and the lateral sinus were continually bathed in foul pus, there were never any signs of toxic absorption.

There was a marked reaction to the first implantation of radium with destruction of tumor tissue for six weeks. The second implantation did not have such a marked effect (Fig. 2).

The patient constantly became weaker until March 30, 1933, when she died in a state of general debility and marasmus.

Autopsy was performed by Dr. Sam H. Gray of the Jewish Hospital of St. Louis. There was a necrotic wound approximately 12x14 cm. covering the right side of neck and face, with its central point about the level of the external auditory meatus. The edges of the wound were irregular and undermined. The ramus of the mandible was completely exposed; the upper level was above the temporal line and the lower border extended to the level of the hyoid bone. Interspersed among the friable necrotic material was woody hard and opaque tissue. The jugular vein and carotid artery were not recognizable in the cancerous mass. The lateral sinus



Fig. 2. Photograph showing extent of involvement four weeks prior to death.

in its bony groove was completely necrotic. Sections taken from the superficial and deeper portions of the wound revealed on histological study a squamous cell carcinoma, grade III (Broders). What was thought to be the remains of carotid artery and jugular vein were identified in masses of carcinoma cells. Muscle and nerve tissue, including sympathetic ganglia, were found in cancer nests. It is interesting to note that no lymphoid tissue was found; even the jugulo-digastric lymph nodes were completely destroyed. There was no evidence of invasion of the neighboring perivascular lymphatics and perineural spaces.

The dura was invaded by carcinoma at one point only (floor of middle fossa), and only a thin layer of normal dura separated the cranial cavity from the cancerous tissue.

No gross or histological evidence of carcinoma was found outside the involved area. The brain, lungs, mediastinum, liver, kidneys, intestines and spleen showed no evidence of metastasis. Thoracic and abdominal chain of lymph nodes were normal. Autopsy diagnosis: Squamous cell carcinoma (grade III—Broders) involving right side of head and neck. No evidence of any metastasis.

CONCLUSIONS.

1. Primary carcinoma of external auditory canal should be sharply differentiated from carcinoma of auricle, middle ear and mastoid.

2. Persistent pain, out of keeping with the objective findings in the auditory canal, is suggestive of early carcinoma.

3. Biopsy is the only definite means of making an early positive diagnosis.

4. Early adequate therapy is the only hope of saving the patient's life.

642 MISSOURI THEATER BLDG.

1017 BEAUMONT BLDG.

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XXXV.

RECOGNITION OF POTENTIAL AGRANULOCYTIC
ANGINA IN OTOLARYNGOLOGY.*

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Since the recognition by Schultz in 1922,¹ of a symptom complex which he designated as angina agranulocytica, there has been almost world wide research and experimentation. Although the etiologic agent of the disease remains unknown, some progress has been made in the matters of diagnosis and treatment with the result that a rapidly fatal mortality, formerly of 80 to 90 per cent, has been reduced to about 26 per cent.² However, a previous attack does not confer immunity, and the so-called recovered cases often become recurrent ones.

In agranulocytic angina there is often absence, or almost absence, of the granulocyte; however, it is essential to recall that there are other diseases with an associated granulopenia. Furthermore, it must be remembered that the granulocyte level is definitely influenced by the ability of the patient to react to the stimulation made. Granulopenia results when the virulence of the organism is far greater than the resistance of the individual, and the normal daily fluctuation in the number of the white blood cells must also be considered.

An understanding of agranulocytic angina involves a knowledge of the mechanism concerned with the formation, destruction and regeneration of the leukocytes.

In a large percentage of the cases of agranulocytic angina there are ulcers of the throat and mouth, and at times of the nose, sinuses and ears. In 1931 Hans Barkan³ reported an ocular involvement—a double-sided ring abscess—complicating a case of agranulocytic angina.

*Presented before the American Laryngological, Rhinological and Otolological Society, San Francisco, Calif., January 14, 1933.

This paper is based upon the study of the data collected from twelve cases of agranulocytic angina, ten fulminant and fatal, two recurrent, a rather extensive review of the literature, personal conversations and correspondence.

A steadily increasing mass of evidence is forcing the conviction that there is, in otolaryngology, a need for the recognition of potential agranulocytic angina, the discovery of which seems to depend, in no small measure, upon careful history taking and differential blood counts.

The major objective of the present paper is to stress the importance of the recognition of the early clinical aspects of agranulocytic angina, in order that one may continuously be alert for its potential development. Too often when the otolaryngologist is consulted, the agranulocytic patient is in the terminal stage of a disease which has already been in process of development for a considerable period of time.

In many of the case histories one finds recorded evidence of similar, but less severe, previous attacks. Furthermore, it has been found that about one-half of the cases of agranulocytic angina present a history of extractions, or some form of oral surgery, in the presence of Vincent's angina just prior to the attack.⁴ In all such cases, a white blood count with differential, prior to the surgical procedure, would reveal the cases of granulopenia and permit the employment of the indicated therapy before any surgery was performed. Doubtless many deaths occur from unrecognized granulopenia, the presence of which is a challenge to diagnostic skill.

Until recently leukopenia has been considered secondary to other factors, an unfortunate complication of other diseases.⁵

Roberts and Kracke⁶ stress the point that the condition of acute granulopenia is characterized by weakness, easy fatigue and tendency to infection. They, Osgood⁷ and others, give it as their opinion that the high incidence of the ulcerative and gangrenous lesions is the result and not the cause of granulopenia.

In a recent personal communication Prof. Kracke remarked: "We have studied over fifty cases of typical Vincent's angina with particular reference to the blood picture. In many of these we

have followed the daily blood picture for a period of weeks. In general, I feel that the infection bears no relation to the etiology of granulopenia."

To the writer it seems reasonable to assume that the sepsis is due to unrecognized granulopenia when the resistance to disease is gravely impaired.

DEFINITION.

Agranulocytic angina is a syndrome or clinical entity whose pathology is probably primary in the bone marrow with secondary septic manifestations, local, general or both.

DIAGNOSIS.

The distinctive points in diagnosis are fever, the septic lesion in the mouth or elsewhere, marked leukopenia associated with agranulocytopenia, no evidence of myelocytes, associated with slight or no affection of red blood cell or platelet. Subjectively there are chill, depression, apprehension, prostration.

ETIOLOGY.

Despite the extensive constructive study of this condition, the fact remains that the etiologic agent has not yet been determined; whether the infection results from the decrease of the granulocytes or the decrease of the granulocytes results from the infection, is still a moot question.

There is a toxic granulopenia, the etiology of which is benzol or arsenic. Leukopenia from the former may result from therapy of coal tar derivatives, the latter from arsphenamin administration for syphilis. Osgood⁷ anticipates that "the cause of the aplasia of the white blood forming elements in the bone marrow will prove to be some poison or toxin." Shea⁸ remarks that "the toxins of the various anginas may stimulate or paralyze the hematopoietic system."

EXPERIMENTAL PRODUCTION.

Kracke⁴ has produced clinical agranulocytosis with benzene and olive oil injected subcutaneously in rabbits, and remarks that the course of the condition seems to be similar to that seen in the human—that is, first a neutropenia, then generalized infection from organisms already present, or from organisms introduced.

BLOOD FINDINGS.

The most impressive point of the agranulocytic angina syndrome is the marked leukopenia produced, which becomes more and more striking as the infection increases. In many cases the count has been found to be from 200 to 300 and at times as low as 100.

The life cycle of the granulocyte is from three to five days.⁶ Therefore, in cases of dysfunction of the bone marrow for five days there would necessarily be a complete disappearance of the granulocyte. Furthermore, it has been determined that their complete absence from the blood stream for a seven day period is incompatible with life, for the reason that the chief barrier to the invasion and multiplication of bacteria is the granulocyte.

In some cases leukopenia has been discovered prior to the development of agranulocytic angina. Doan⁷ and others call attention to the fact that since the establishment of blood counting as a routine in clinical diagnosis, physicians have observed a tendency to leukopenia as an important part of the clinical syndromes of certain well known diseases. Notably among them are influenza, tuberculosis, typhoid, overwhelming infections with the pneumococcus and streptococcus. Various toxic agents, benzene, the arsenicals, X-ray, gamma rays of radium, etc., have been discovered to be the cause not infrequently of a profound leukopenia.

To observers in the past, leukopenia has always been considered secondary to other factors, and not as presenting any significant signs or symptoms due to the deficiency in the white blood count. Among the first to recognize the value of analyzing accumulated data in this regard were Roberts and Kracke. They reviewed the records of 8,000 private clinic patients, finding one of every four having mild granulopenia; one of every two women patients between the ages of 40 and 60 years was neutropenic; and complaints of weakness, exhaustion and fatigue were twice as frequent in the granulopenic individuals as in those showing a normal white blood count.

ARSPHENAMIN.

Several cases have been reported in the literature of agranulocytic angina allegedly due to arsenic therapy in syphilis as well as in Vincent's angina. Probably since relatively a small percentage

only of the cases are thus affected, there is in these cases a preceding special weakness of the leukopoietic apparatus.⁹ Farley¹⁰ warns that one should be alert to recognize early symptoms of bone marrow weakness in patients who are to receive arsphenamin treatment.

X-RAY AND RADIUM.

The fact that roentgen ray and radium irradiation are capable of producing a similar clinical picture to that of agranulocytic angina seems to the writer to demand the maximum of caution by those who employ this therapy, as well as frequent blood checking by the hematologist.

ANTITYPHOID.

In a recent conversation, David P. Barr remarked that "agranulocytic angina has been known to follow antityphoid injections." One who has a chronic granulopenia should always be regarded as a potential candidate for the development of an acute attack.

PATHOLOGY.

The writer subscribes to the belief of others that the so-called "putrid sore throat," seen and described by the otolaryngologists of the last century, represented the condition that is now known as agranulocytic angina. The lesions present overhanging edges with frequently no surrounding inflammatory zone. There are often ulcers along the gingival margins, on the tonsils, pharynx and sometimes in the larynx and esophagus. The pathologic lesion of the bone marrow is less obvious and is difficult to describe.

INFECTIOUS OR CONTAGIOUS.

As one concrete example of proof that agranulocytic angina is not infectious or contagious the writer recalls an incident of a young girl in the terminal stage of the disease (a patient of a local colleague, Dr. Stealey), whose mother could not be prevailed upon to desist from kissing the sick child upon the lips and holding her in her arms, even when the end came. The mother did not contract the disease.

IMMUNITY AND RESISTANCE.

Immunity and resistance¹¹ to agranulocytic angina seems to depend upon that phase of the function of the bone marrow which

has to do with the genesis of the granulocyte. The foreign body in the blood is engulfed by the polymorphonuclear neutrophil and, if digestible, destroyed by ferments in the body of the cell. The granule of the leukocyte is presumed to supply the ferments which constitute the chief barrier to bacterial invasion and multiplication. The daily renewal of immunity, due to the genesis of the polymorphonuclear neutrophils, is lost in the event of dysfunction of the bone marrow.

In general, it may be said that in many pathologic processes, including agranulocytic angina, the potential leukocytosis is proportionate to the resisting power of the patient and depends as much and probably more upon the ability of the patient to react, as to the stimuli applied.

ENTITY OR SYNDROME.

There is still remaining a division of opinion as to whether agranulocytic angina is an entity or only a syndrome. In a recent personal communication from Prof. Schultz, who first described the condition, he remarked that he believes "agranulocytosis is a syndrome and a sickness; that there is a residue even after years!"

THERAPY.

In consideration of the therapeutic measures which will favorably influence the course of the disease, the result accomplishment of the Nucleotide Committee of the Harvard Medical School can scarcely be overestimated. The chairman of this committee, Dr. Henry Jackson, presented in September, 1932, an analysis of sixty-nine cases of agranulocytic angina treated by pentose nucleotide K96, with recoveries of 74 per cent.² These cases were reported by forty different physicians in twelve different states. The mortality is the lowest of any published series of like size. The favorable clinical and hematologic response took place rather sharply about the fifth day of treatment, irrespective of how long the patient had been ill prior to treatment. The subsequent hematologic improvement in practically all cases followed the same orderly pattern.

From the literature it is obvious that blood transfusion is next of choice. Osgood⁷ remarked that "the most logical treatment is

blood transfusions in large numbers and in large amounts." Reznikoff remarks:¹⁸ "Adenine sulphate therapy in fifteen uncomplicated cases of agranulocytosis has been followed by recovery in eleven of the patients. One gram of adenine sulphate boiled in 35 to 40 cc. of saline, given warm, intravenously three times a day, for at least three days for an adult, is nontoxic, and is suggested as the dose in treating agranulocytosis in adults."

CASE REPORTS.

Female, white; age, 50; patient of Dr. J. W. Sherrill, March 5, 1931.

This woman was always well; a nervous type, very active; married twenty-five years. Until a few years ago drank a large amount of alcohol. Artificial menopause by radium several years ago. About six weeks previous patient had cold, sore throat, temperature 102 degrees. Recovered in forty-eight hours. About three weeks later she had similar attack of sore throat with temperature of 103 degrees, lasting two days. There was nausea, loss of appetite, weakness. Had been in La Jolla about one week. Last night, midnight, had chill (septic invasion). This morning (5th) she felt much better, but complained of a cold and the throat was slightly sore. At 5:00 p. m. of this day, upon examination, she appeared to have an ordinary cold, eyes injected, throat "a little bit sore," but this was not the primary feature. Examination revealed a septic area on the right tonsil stump, upper pole. (Tonsillotomy had been performed about fifteen years previously). She was ordered to bed immediately. She complained of slight nausea, temperature 101.

March 5, 1931. 5 p. m. Admitted. White patch on right tonsil, throat sore.

March 6, 1931. Was seen by the writer. Complaints of sore throat. Patch on right tonsil increasing. Necrotic large area below lower pole of left tonsil. Adenitis right side of neck, lips parched, tongue and mucous membrane red and inflamed, eyes injected. Patient exhibits marked apprehension; complains of being "deathly sick."

Taking some orange juice and water; complains of difficulty in swallowing.

March 7, 1931. Bilateral adenitis much more marked, tense and painful on slight pressure. Patient very toxic.

March 8, 1931. Died this morning, sixty-four hours after admittance. The course of the disease was rapid and without benefit from the blood transfusion, adenine sulphate (intravenous) or roentgen ray therapy.

The septic areas of the throat became increasingly necrotic without displaying a ring of inflammatory reaction. There was progressive increase in the size of the cervical glands, and boardlike hardness and fullness of the neck developed. There was no fluctuation and no local inflammatory reaction at the site of these areas. The lips were dry and there were a few subcutaneous hemorrhages at base of tongue.

Membranes of the eyes were congested, but there was no true inflammatory reaction. Maximum temperature, 105. Pulse, 164. Respiration, 20. March 6th, the initial white blood count was 1,800; lymphs, 100 per cent. On the following day the white blood count was 800. Polys, none found.

Male, white; age, 56; physician; patient of Dr. L. A. Kennell.

This man was generally well and active, until he went to bed April 5, 1929, with gangrenous chickenpox. The disease was contracted from his children, who all had the usual trivial form just prior to his illness.

The patient was in bed for more than a month; was seriously ill; toxic; temperature to 104 degrees. His physician remarked: "He went to bed a middle-aged man and got up an old man." His health remained impaired, thereafter having insomnia, headache, backache, shifting pains, easy fatigue. Refused blood count, which for more than one reason was most unfortunate.

On October 1st, while absent from the city, patient became acutely ill. There was fever and two rapidly appearing necrotic areas on left side and left base of tongue. The following day a painful lesion developed in left external auditory canal which kept him awake all night. October 3rd, he consulted an aurist who opened the ear lesion finding no pus. Temperature 103 degrees. Patient was ordered to bed, but returned to San Diego, that he might be at home.

October 4th, at 7:00 a. m., Dr. Kennell was called. Patient said he was under such apprehension and pain that he could not get to sleep. He was given morphine sulphate, gr. 1/4, and slept for several hours. At 2:00 p. m. white blood count was 1,400, no polys found. Leukocytic extract and other approved treatment was administered with no response whatever. Patient died 24 hours after admission to hospital. Maximum temperature, 104 degrees. Pulse, 140. Respiration, 40. Last white blood count, 120; no polys found.

Death took place about five months subsequent to the patient's recovery from gangrenous chickenpox. It seems probable to writer that in this case there remained a granulopenia following the malignant chickenpox, with an associated impairment of resistance to infection, and that a paralytic of the hematopoietic system resulted.

The writer chose this case for the reason that there seems to be no similar report in the literature.

Male, white; age, 48; physician; patient of Comdr. R. G. Davis (M. C.), U. S. Naval Hospital, San Diego, Calif.

This man was always well until June, 1930, when dental work and extractions were performed in the presence of Vincent's angina. A general peripheral neuritis developed and became quite troublesome. Oral surgery was continued with interruptions, for about a six months' period, when on January 20th, 1931, patient had a complete general examination, with the result of a white blood count of 5,500 being the only abnormal finding.

On February 2nd there was general malaise, chill, evening temperature of 99 degrees—which within four days gradually increased to 104 degrees. A small necrotic area developed on the buttock. Cathartics did not relieve constipation. White blood count, 800. Blood transfusions daily for three days. Repeated white counts below 1000. There were two necrotic fissures in ano which healed when white blood count reached 3,000. The lost appetite returned after first transfusion. One-twentieth erythema dose of X-ray to the long bones February 8th and 10th was made. The white blood count gradually rose to 3,000 in the first two weeks, and without interruption continued to increase until April 6th, when patient was transferred to the U. S. Naval Hospital, San Diego, for further observation.

The main precipitating cause of the agranulocytic angina seems to have been the overwhelming infection of the bone marrow because of the oral surgery at the time of a marked granulopenia.

This patient has had further recurrent attacks (often precipitated by fatigue) for a period of about two years, and each time has responded to injections of leukocytic extract, minimal doses of X-ray radiation to long bones, and blood transfusions when necessary. For three consecutive days Pentose Nucleotide K96 was employed according to the rules of the Nucleotide Committee of the Harvard Medical School. In this particular case, however, the patient responded better to the leukocytic extract.

The minimum white blood count was 200, with total absence of polys. At no time during the two-year period has the white blood count been more than 5,500.

The writer selected this case for two reasons: First, it is an example of the discovery of a low white blood count before an attack of agranulocytic angina. Second, the two-year hematologic study representing about 250 differential blood counts.

From an ingenious chart of the blood picture for more than two years, made by Comdr. Davis, the hematologist, Comdr. W. W. Hall, remarked that the chart indicates a definite reduction of granulocytes during the course of illness, at periods very marked, and at some of those periods a practical absence of granulocytes which justified classifying the case as one of granulopenia or agranulocytosis. That in his Schilling count he has continually demonstrated a high percentage of immature forms indicating the rapid production of granular leukocytes in the bone marrow, and rapid liberation of those forms. This indicates that in this case the granulocytopenia occurs not as a result of the failure of genesis of the granular leukocytes in the bone marrow, but as a result of a rapid destruction of these cells after liberation, either due to a toxin or an inherent defect or tendency toward degeneration in those cells, the balance of degeneration and regeneration being such that a granulocytopenia of greater or lesser degree has persisted throughout the course of observation.

Female, white; age, 31; patient of Dr. C. L. Stealey.

This woman was well, full of life, active socially; married three years.

From October, 1929, to April, 1932, patient had had recurrent attacks of slight temperature, general aching, headache, and at times slight nausea—rather typical of the so-called influenza. Blood counts were made from time to time between attacks, and presently one differential white blood count revealed increase of lymphs and decrease of polys. This created suspicion, and subsequently frequent white blood counts were made.

On April 12, 1932, patient was taken with a chill and hospitalized. White count, 800; lymphs, 100 per cent; polys, one found.

Responded favorably to nucleotide K96. White blood counts at frequent intervals following this attack were not far below normal.

In November, 1932, there was a recurrent attack; white count 1,100; lymphs 100 per cent; polys, none found. Responded favorably as before to nucleotide K96.

The prodromal symptoms of each attack in this case were: trembling, blurring of vision, chilling, lassitude, fatigue, exhaustion—directly proportionate to the white blood count.

Another phase of clinical interest was that of the subjective symptoms of influenza over a three-year period, and without the white blood counts the acute granulopenia would have been overlooked, and another death charged to influenza due to failure in meeting the challenge of diagnosis.

This case was selected because of its special bearing on the problem presented by the paper—the discovery of a low white blood count prior to an attack of agranulocytic angina.

Male, white; age, 60; patient of Dr. H. J. Stewart. July 17, 1931.

This man was of a nervous type; was underweight; had drunk alcohol excessively for several years. For six weeks he had had arthritis and for about a month his right eye had pained him considerably. For past two weeks he has been delirious most of the time.

Examination revealed swelling of the upper lid of the right eye, three ulcers of the conjunctiva of this lid, no pus in eye. Dental hygiene was unusually bad. There was marked Vincent's angina with excessive ulceration of the gingival margins and of the posterior portion of the right alveolar process. There were ulcers on tip of tongue and pharyngeal pillars. There was marked general weakness.

July 17, 1931, the white blood count was 1,400, polys 1 per cent. July 20, 1931, the white blood count was 2,400, no polys found. Therapy—X-ray of long bones. Died July 23, 1932.

Autopsy by Dr. H. A. Ball revealed no important pathological change other than hypostatic pneumonia and early cardiac vegetation.

Examination of bone marrow disclosed little evidence of regeneration. Smears of this tissue revealed large numbers of red blood corpuscles, but only a few white blood cells. During twenty minutes' search only two white cells, which could be definitely identified as such, were found.

SUMMARY.

From the literature agranulocytic angina seems to be pre-eminently a disease of physicians. Of the twelve cases of the present study, two were physicians ($16\frac{2}{3}$ per cent). Nine of the patients were female (75 per cent), three male (25 per cent). Of the female patients there was one possible example of familial taint or tendency, a fatal case, whose sister, the writer was informed by her physician, Dr. Harry E. Mason, has recurrent attacks.

Another female case (with an allergic history) showed marked protein reaction following blood transfusion.¹² This case had recurrent attacks for more than two years; recently a fatal attack.

Of the fatal cases, three had been excessive users of alcohol.

Granulopenia seems to be a disease which may be acute or chronic, severe or mild.

Agranulocytic angina appears to be a manifestation of granulopenia when the polys are from absent to 4 per cent.

Possibly the earliest blood picture suggesting imminence of an attack of granulocytopenia is a shift in the relative percentage of lymphs to polys—a slight decrease in the polys with a relative percentage increase in the lymphs.

The literature seems to justify the statement that increased care should be given to history taking and that more frequent differential blood counts should be made.

The literature seems also to confirm the assumption that importance should be attached to the early recognition of the septic lesions by the otolaryngologist and the dentist, that warning may be sounded to the internist, in order that there be no unnecessary delay in the correlation of diagnosis and therapy.

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XXXVI.

THE MICROSCOPIC ANATOMY OF THE EUSTACHIAN
TUBE.*

DOROTHY WOLFF, PH.D.,

ST. LOUIS.

We are indebted to Henle for the first accurate description of the microscopic anatomy of the eustachian tube. This author's description of the tube can scarcely be improved. He stated that like the outer ear it consists of a bony and cartilaginous part and that its length is approximately 35 mm. "The canal has, as a whole, a diagonal direction almost exactly between the transverse and the sagittal, at the same time with an inclination downwards." Henle was the first to see the similarity in shape of the cross section of the cartilage to that of the shepherd's crook, "*Hirtenstabkrümmung*." He noted that the mucous glands were more numerous near the pharynx than near the tympanum. He observed that the main cartilage was separated by strands of perichondrium which first appeared near the middle of the course of the cartilaginous tube, and that at the lower end some cartilaginous pieces were completely separated from the main cartilage. He believed that through the intervening spaces of the split cartilage passed the ducts from the mucous glands to the lumen. He stated that the epithelium of the tube along its whole length is ciliated and that the direction of the ciliary movement is from the tympanic cavity toward the pharynx. Most accurately he illustrated the position of the tube in the bony skull and depicted with colors the muscles related to the tube.

During the 1870's we find such careful observers as Zuckerkandl, Rüdinger, Moose and Urbantschitsch debating in regard to the physiology of the tube and whether or not it is normally

*Read by invitation before the American Otological Society, May, 1933. From the Oscar Johnson Institute, Department of Otolaryngology, Medical School, Washington University, St. Louis.

This work was made possible by the Ball Research Fund.

open or closed. Practically each article contributes some new anatomic observation.

Rüdinger, in 1871, stated that while the eustachian tube of man and of the various species of animals is constructed on the same general plan, a practiced observer can tell, from the examination of a transverse section alone, the name of the animal from which it was obtained. He says the osseous portion of the tube forms an elongated triangular fissure, the greatest diameter of which is vertical. The base of the triangle is above. "As the bony end of the median tubal opening appears dentated and obliquely cut at its point of junction with the cartilage it is more largely bound by osseous substances mesially and posteriorly than anteriorly, and laterally, an arrangement which, as Henle has already remarked, is deserving of notice to enable us to understand the mode of attachment of the cartilage to the bone.

Rüdinger says he can corroborate the statement of Von Troeltsch and L. Mayer that a direct passage of the musculus dilatator tubæ (our tensor veli palatini) takes place into the tensor tympani.

Zuckerkindl, in 1874, tried to imitate the action of the muscles of the tube on a cadaver. He also described and illustrated six accessory cartilages on a tube. They lay on the lateral and inferolateral surface of the tubular cartilage and were connected with it by connective tissue. They were movable.

Moose, writing in 1874, continued the physiologic discussion and contributed the anatomic description of clefts occurring in the mucosa, a point which Henle had intimated.

Teutleben, 1877, made an attempt to classify the various types of auditory tubes on the basis of the type of lymphoid tissue present. Gerlach had previously described the tubal tonsil. Teutleben, working at a later date, decided that not only might there be a definite tubal tonsil but that there might also occur a diffuse condition of the lymphoid tissue. His classification into three types, however, is really more suggestive of three stages in developing infection. His illustrations and verbal descriptions seem to indicate that this diffuse type corresponds to our diffuse round cell infiltration. Only one of his illustrations gives the complete cross-section of the lumen.

In the year 1884 a textbook on diseases of the ear by Urbantschitsch was published (*Lehrbuch der Ohrenheilkunde*). This author devoted nine pages of small type to the anatomy and physiology of the tube and ten pages to its pathology. He described the auditory tube as having the structure of a flat double nine-pin, the bodies being joined at the so-called isthmus tubæ.

Urbantschitsch stated that the tubular cartilage fuses with the basilar cartilage of the base of the skull. (Incidentally, I may say, we have no proof of this in the sections collected in the Oscar Johnson Institute. To me the tubular cartilage seems, from cases observed, to be a distinct unit.)

The statement is also made that the width of the infant tube is 3 mm., being about 1 mm. wider than that of the adult. This observation was made by von Troeltsch. (The material in the Oscar Johnson Institute shows no such width, but it is not impossible that the tube could be distended 3 mm.)

Since the opening of the Institute twenty-five cases showing eustachian tube have been sectioned in this laboratory. In age these range from less than 2 months to 51 years. A complete series in vertical plane, of a normal 44-year-old adult has been obtained, the block extending from the mastoid antrum forward to the pharyngeal end of the eustachian tube. There is also a horizontal series through an adult of 51 years. There are two complete vertical series of infant tubes (6 months). While many of the other specimens are incomplete, nevertheless, they are of sufficient extent to present an informative picture.

The youngest specimen is an embryo of less than 2 months. At this age there is no differentiation of epithelium along the course of the tube, although lingual epithelium is well differentiated.

In an embryo (XV M256), estimated to be $2\frac{3}{4}$ months, is seen the direct continuation of the middle ear cavity with the nasopharyngeal cavity. The length of the tube is 2 mm. The tube has a patent lumen throughout, and it will be noticed that even at this early age there is a narrowing in the middle of its course. It is here that the isthmus is designated in the adult. This narrow part measures .062 mm. in the plane of the section and approximately .02 mm. in the vertical plane. A differentiation of

epithelium has already occurred along the tube as far as the middle ear cavity on the medial side and over a part of the membrana tympani on the lateral side. The differentiation is not so advanced as that on the nasal mucosa, however, which exhibits high ciliated columnar cells. It may be noted that the pharyngeal ostium is approximately on the level of the hard palate for the tooth buds can be seen. Kölliker has pointed out, according to Urbantschitsch, that this ostium lies half way under the hard palate, in the fetus, at the same level in the newborn, 4 mm. above it at 4 years old and 10 mm. above it in the adult.

A 3-months embryo, Fig. 1, shows the fibers of the tensor veli palatini passing around the hamulus of the sphenoid bone and thence passing over to the palate, while the fibers of the levator veli palatini pass directly on to the palate. At this age the tensor tympani lies in a quite isolated position along the apex of the cochlea. It has not yet developed sufficiently to meet the handle of the malleus. No connection was observed between it and the tensor veli palatini.

In a 4-months fetus (XVII M277) the pharyngeal end of the tube is seen to be horizontally flattened and to lead into the pharyngeal cavity by a rather constricted passageway which itself is .87 mm. long. This formation is probably the beginning of the "Janitor" of which Eustachius speaks—the torus tubarius.

By this time the epithelium is differentiated into ciliated columnar cells interspersed with goblet cells. The cells are not uniformly differentiated around the diameter of the lumen. Near the pharynx are seen acinous glands which already show a mixed type of structure. The long axis (horizontal) of the tube at this level measures 1 mm. The short axis (vertical) measures .25 mm. Rugæ, characteristic of digestive tract lumen, are present. The medial cartilage is already present. Kölliker states that the tubal cartilage first appears at 4 months. Valentine finds it present at 3 months (Urbantschitsch). The cartilage in this specimen extends for a distance of 2 mm. auralwards from the pharynx. It appears to have about four centers of development and is tortuous. No superior cartilage has as yet formed. The lumen narrows midway in its course and there is a rotation of cross sectional axes. The longer axis gradually assumes a vertical position,

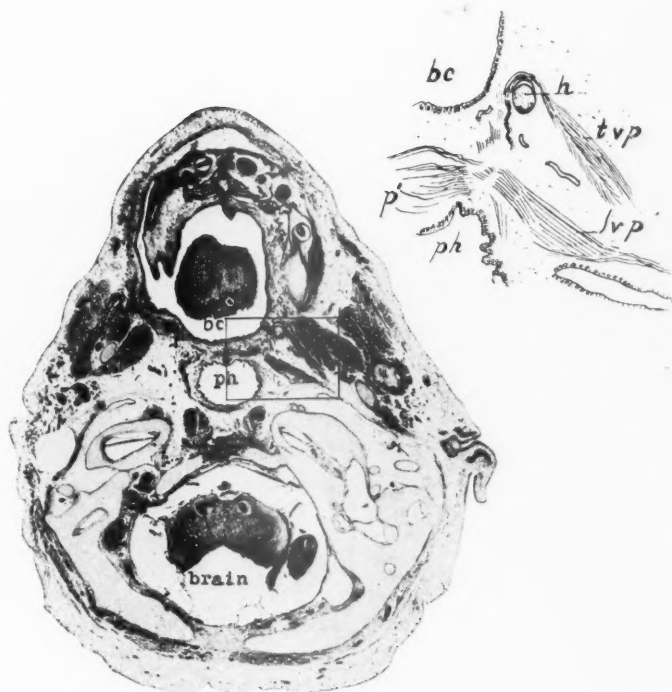


Fig. 1. Horizontal section through the head of a 3-months embryo showing tensor veli palatini fibers passing around the hamulus of the sphenoid while levator veli palatini fibers pass directly onto the palate.

KEY TO ABBREVIATIONS USED IN FIGURES.

- | | |
|--|--|
| <i>apc</i> —ampulla canalis posterior | <i>m</i> —malleus |
| <i>bc</i> —buccal cavity | <i>mt</i> —membrana tympani |
| <i>c</i> —cochlea | <i>lvp</i> —levator veli palatini |
| <i>ca</i> —carotid artery | <i>p</i> —promontory |
| <i>cc</i> —carotid canal | <i>p'</i> —palate |
| <i>cart</i> —cartilage | <i>pa</i> —paranasal cells |
| <i>cst</i> —caput stapedius | <i>ph</i> —pharynx |
| <i>ET</i> —eustachian tube | <i>pt</i> —peritubal cells |
| <i>ext. aud. can.</i> —external auditory canal | <i>rf</i> —recessus pharyngeus (Rosenmüller's fossa) |
| <i>fn</i> —facial nerve | <i>tvp</i> —tensor veli palatini |
| <i>h</i> —hamulus of sphenoid | <i>v</i> —vestibule |
| <i>i</i> —isthmus | |

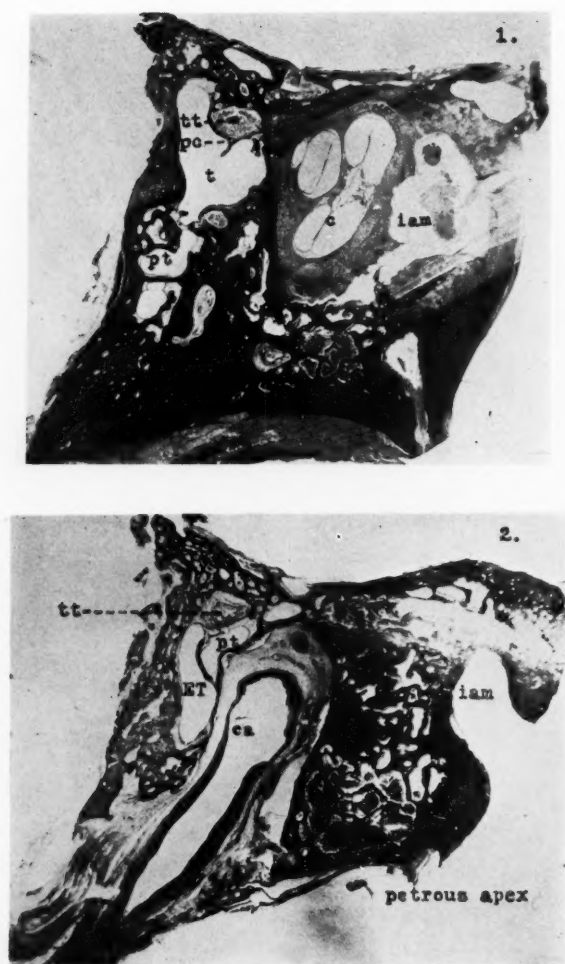


Fig. 2a. A series of vertical sections through the left eustachian tube of a 44-year-old male.

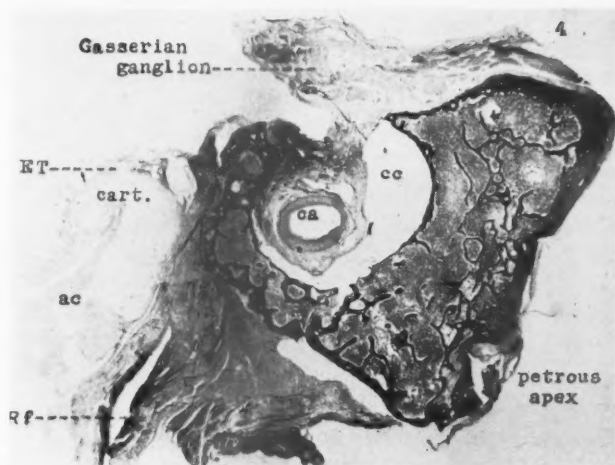
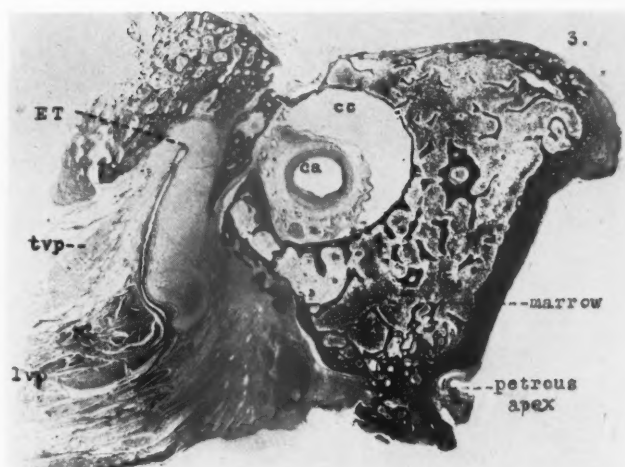


Fig. 2b. A series of vertical sections through the left eustachian tube of a 44-year-old male.

the shorter a horizontal. This shift is probably the cause of the torsion of the fetal tube described by Hammar and mentioned by Keibel and Mall.

In a 6-months premature infant the medial cartilage extends toward the tympanum, even beyond the apex of the cochlea. This condition is maintained at birth and was observed in an infant as old as 10 days.

By 2½ months the bony tube is well developed. In the infant of 6 months a well defined isthmus was observed, the lumen being 2 mm. in height and .32 mm. in width. This width could conceivably have been distended to 3 mm. before bony wall would be encountered. A tubal tonsil (lymphoid nodule) may occur in the pharyngeal end of the tube. Further details of conditions of the tube in a 6-months infant have been previously presented in the literature by the author.

The isthmus of a normal adult tube measured 5 mm. in height, 1 mm. in width, this latter measurement expanding to 1½ mm. inferiorly. The lumen of this specimen could not have been distended because of the surrounding bony wall. (Isthmus is considered as the first point where cartilaginous tube appears.) Four or five "accessory" cartilages were observed, all but one of which were really a part of the main cartilage, as was proven by the construction of a model.* This one isolated cartilage was quite small and occurred in the midst of mucous glands between tensor and levator veli palatini muscles. (See Fig. 2.)

Cellulae tubarii or paratubal cells may be as large as or larger than the main lumen. They do not normally communicate with the main tube, but are diverticula of the tympanum. In pathologic cases, however, suppuration may break through from a diseased tube into these cells. The infection may then pass forward into the petrous apex. The lumen of the pneumatic cells may become lined with ciliated epithelium.

The eustachian tube has in close proximity to it two important anatomic structures. These are the internal carotid artery

*A blotting paper model of the tube illustrated in Fig. 2 was constructed. The author is indebted to Miss Ila Scott for generous assistance in the detailed technical work involved.

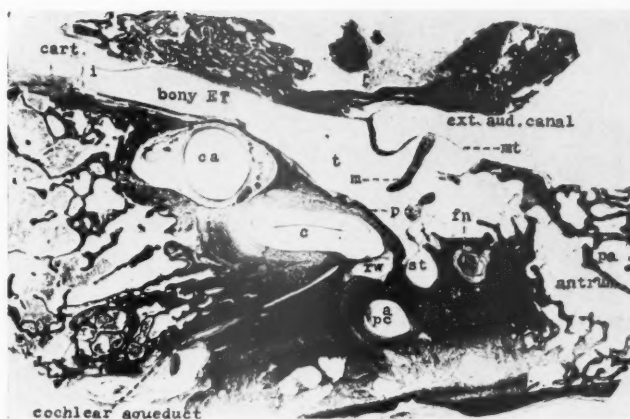


Fig. 3. Horizontal section through the right temporal bone of a 48-year-old colored female. Observe the close proximity of the thin-walled carotid canal to the bony eustachian tube.



Fig. 4. Horizontal section through an infected eustachian tube of a 5-year-old white female child, death due to influenzal meningitis.

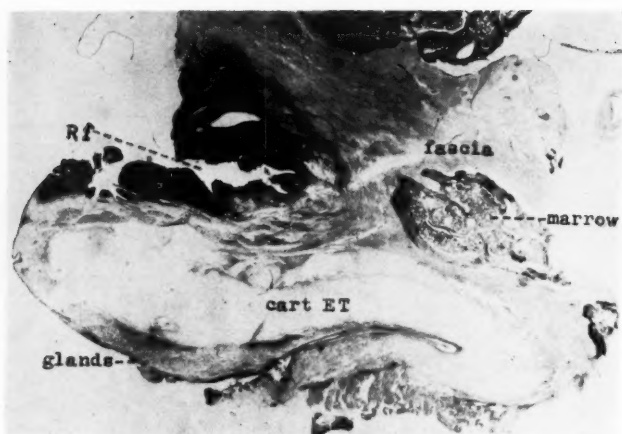


Fig. 5. Horizontal section of the eustachian tube showing its relation to recessus pharyngeus (Rosenmüller's fossa). White female, 27 years.



Fig. 6. Stricture of eustachian tube with partial obliteration of the epithelium. Colored female, 51 years.

and the recessus pharyngeus or Rosenmüller's fossa. The intimate relation of the internal carotid to the bony eustachian tube is well illustrated in Fig. 3. Spontaneous dehiscences and anatomic apertures for the passage of vessels and nerves have been illustrated elsewhere.

Fig. 5 presents the close relationship existing between Rosenmüller's fossa and the tube. The fossa may extend superiorly beyond the level of the cartilaginous tube. It is characterized by a luxuriant growth of lymph follicles.

Pathologically the tube may develop polyp-like growths at the tympanic orifice. These may become infected as seen in Fig. 4. In a case of stricture of the tube in a patient aged 51 years, the number of glands was greatly reduced. The connective tissue of the submucosa was more dense and fibrous than normal. The lumen was obliterated at a point 2 mm. below the isthmus. At the isthmus it was widely patent. The epithelium at the stricture was neither columnar nor ciliated but was flat and in areas showed complete atrophy and obliteration (Fig. 6).

An examination of animal tubes (monkey, cat, rabbit, white rat and guinea pig) showed great variation in the structure of this organ. One feature they seemed to possess in common in contrast to human material. This feature was that the lumen appeared widely patent throughout. The cat presented the most complicated structure of the tubes studied. Its tube was somewhat U-shaped, bearing a circular expansion (the Hilfsröhre of Rüdinger) which in part of its course was completely separated from the rest of the tube. This tube showed evidences of infection.

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XXXVII.

GROWTH AND DEVELOPMENT OF THE NASO-
RESPIRATORY AREA IN CHILDHOOD.*

HARRY C. ROSENBERGER, M. D.,

CLEVELAND.

INTRODUCTION.

The Bolton Fund, in co-operation with the Brush Foundation, is making a study of the growing child to correlate physical and mental growth. Children are examined at three-month intervals during the first year of life, at six-month intervals up to five years of age and thereafter at yearly intervals. Our particular interest in this investigation has been the development of the nasorespiratory area.

For this survey we have investigated the serial roentgenograms of the skulls of 69 boys and 73 girls ranging in age from birth to 19 years. Although each child has been X-rayed several times at intervals of three months to a year according to the plan just mentioned, we have confined our attention in this initial study to the lateral roentgenograms of the first growth interval recorded.

The roentgenograms were made available through the courtesy of Doctor B. Holly Broadbent, director of the Bolton Fund, Western Reserve University.

Early in the investigation it was evident that upper respiratory obstruction can be subdivided into two types. Anterior obstruction or occlusion of the nasal chambers is produced by turbinate congestion or enlargement complicated by septal swelling or deviation. Posterior obstruction is produced by adenoid overgrowth of the pharyngeal tonsil. Associated with either type of respiratory obstruction there is frequently an anomaly in growth of the

*From the Laboratory of Anatomy, School of Medicine, Western Reserve University.

Presented as a candidate's thesis to the American Laryngological, Rhinological and Otological Society, and read by title at the annual meeting in Charleston, S. C., April, 1934.

upper facial or nasomaxillary area, a condition which often repeats itself in siblings of the same family or in parent and child. It has been customary to ascribe the anomaly in upper facial growth to hereditary causes. This investigation has been conducted without preconceived theories upon the causation, for it was our aim to study the course rather than the cause of anomalous growth, leaving the consideration of cause for later analysis when our knowledge of the facts should be more complete.

The work of Todd and Wharton on the developing face of sheep thyroidectomized at about 1 month of age, a study which as yet has been published only in preliminary notes,² demonstrates that bodily growth disturbance in early life may profoundly and permanently affect the course of rapidly growing areas like that of the face, and indicates that constitutional health as well as heredity must be considered in the ascription of a cause. Whatever be our ultimate equation of these two factors, heredity and constitution, in the production of aberrant facial growth, we are not in a position to consider either intelligently until the principles of facial growth have been defined and the course of growth outlined both in normal and aberrant examples.

METHOD OF STUDY.

The validity of the roentgenograms as research material for growth study depends upon the accuracy with which these roentgenograms portray and measure the morphologic features. The child's head is firmly held in the Broadbent-Bolton cephalometer, a device designed to assure identity of orientation in serial roentgenographic examinations of the head. The X-rays are taken with the head adjusted to the Frankfort horizontal, hereafter referred to as F. H. This horizontal on the cephalometer utilizes the upper margin of the external auditory meatus (porion) on both sides and the lowest point on the margin of the left orbit (orbitale). In our study the Frankfort horizontal serves the purpose of a standard plane of orientation but not as the zero mark for measurement of growth.

The skull contours are traced from the X-rays on translucent paper, and particular note is made of the following significant features shown in Fig. 1: porion (*P*), orbitale (*O*), nasion (*N*),

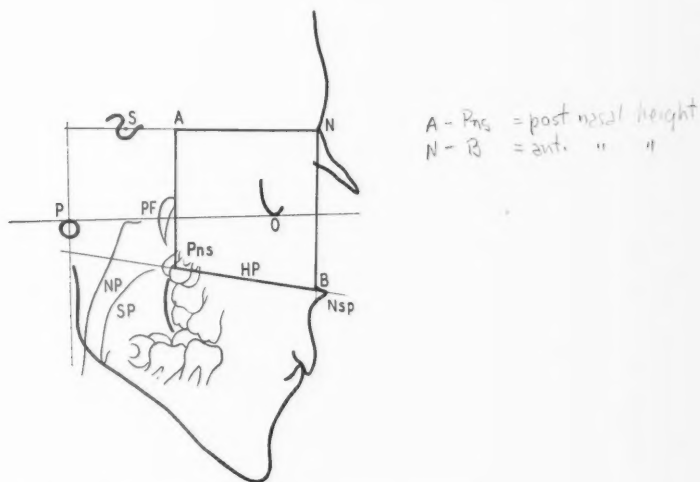


Fig. 1. Tracing of skull contour showing the features necessary to an analysis of growth in nasorespiratory area and upper face. For details see text.

anterior (*Nsp*) and posterior (*Pns*) nasal spines, midpoint of sella turcica (*S*), pterygopalatine fossa (*PF*), the margins of which, followed downward, indicate the position of the posterior nasal spine, posterior wall of nasopharynx (*NP*), cribriform plate, hard (*HP*) and soft (*SP*) palates, erupted and erupting teeth.

The Frankfort horizontal is depicted on all tracings. A perpendicular to the F. H. is erected through porion. A line is then run through the hard palate, including the anterior (*Nsp*) and posterior (*Pns*) nasal spines intersecting the porionic vertical. Another line connects nasion (*N*) with midpoint of sella turcica (*S*), and is of importance as denoting the approximate position of the cribriform plate, which forms the roof of the nasal cavity and the floor of the anterior cranial fossa. Two lines are erected at right angles to *NS*, the one from the posterior nasal spine (*Pns*) intersecting *NS* at point *A*, the other from nasion (*N*) intersecting the line *Nsp-Pns*, or its projection, at point *B*. The line *NB* measures anterior nasal height and the line *Pns-A* posterior nasal height.

GROWTH OF NASORESPIRATORY AREA AND ITS RELATION TO
NASOPHARYNX UNDER FIVE YEARS.

This part of the study is based upon measurements of the nasorespiratory area in twenty-six white boys and twenty-eight white girls from 3 months to 5 years of age. Nine boys and twelve girls were selected as standards because they showed average growth in height and weight as determined by the Woodbury tables, and average physical development as indicated by Todd's skeletal maturation criteria.⁴ The progress of normal nasorespiratory growth is thus based upon a study of the normal healthy child.

It is obvious that we are dealing with a small sample in the specific analysis of nasorespiratory development, but our standards are a normal group of children chosen from a healthy population. We shall point out an apparent general pattern of nasorespiratory growth and its relation to nasopharynx, and discuss the effects of certain aberrant forms of upper facial development.

The measurements of the nasorespiratory area are, in length (*a*), roof (*NS*) and (*b*), floor (*Nsp-Pns*), and in height (*a*), anterior (*NB*) and (*b*), posterior (*Pns-A*). In addition the dimension *AS* is measured.

THE STANDARD SERIES OF NORMAL BOYS.

Table 1 gives the dimensions of the nasorespiratory area in the nine boys chosen as standards on account of their constitutional health.

TABLE I.

DIMENSIONS OF THE NASORESPIRATORY AREA IN NINE WHITE
BOYS CHOSEN AS STANDARDS.

Age	Length		Height	
	Roof (<i>NS</i>)	Floor (<i>Nsp-Pns</i>)	Anterior (<i>NB</i>)	Posterior (<i>Pns-A</i>)
3 months.....	50.0	36.0	28.0	21.0
6 months.....	50.0	36.0	31.5	27.5
9 months.....	52.0	36.0	33.0	29.0
2 years.....	57.0	42.0	38.5	31.0
3 years.....	60.0	43.0	40.5	34.5
4 years.....	61.5	43.5	42.5	37.5

The roof of the nasorespiratory area, in this series, does not grow appreciably until some time between the ninth month and second year. Allowing for the longer time interval, the rate of growth is not much greater than before nine months or after two years. In general, the rate of growth after six months is steady, even and not very rapid.

The floor of the nasorespiratory area is stable until after nine months. From this time on there is a steady growth, faster at first, but slowing down after two years. The contrast with roof length is important: roof has gained 11.5 mm., floor only 7.5 mm. The gains are respectively 23 per cent and 21 per cent. Roof is growing faster than floor.

The growth of the nasorespiratory area in anterior height is relatively rapid and most vigorous under two years.

Growth in posterior height contrasts with growth in roof and floor, and to a less extent with growth in anterior height. The two periods of most rapid growth are below nine months and above two years. When anterior and posterior growth in height are compared it is noted that anterior height has gained 14.5 mm., posterior height 16.5 mm. These are gains respectively of 52 and

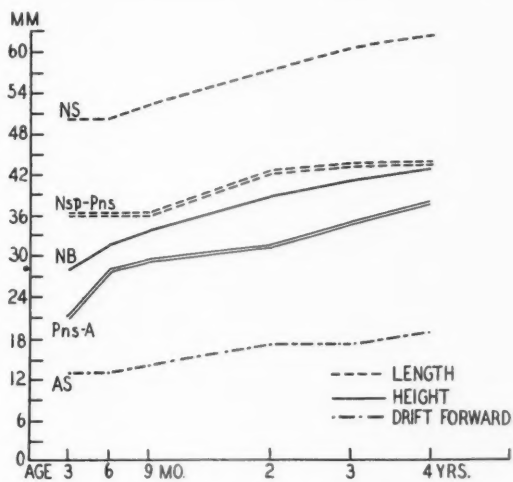


Fig. 2. Nasorespiratory area. Boys, under 5 years.

79 per cent. The actually and relatively greater growth in posterior height is of importance to the opening up of nasopharynx as we shall see later.

Fig. 2 plots the increments of growth in the white boys chosen as standards and emphasizes the distinctions already noted in Table 1. Floor is shorter than roof; posterior height is shorter than anterior; roof grows faster than floor; posterior height grows slightly faster than anterior; length increase is gradual and does not start until about nine months; height increase is more rapid and manifests itself vigorously between three and six months.

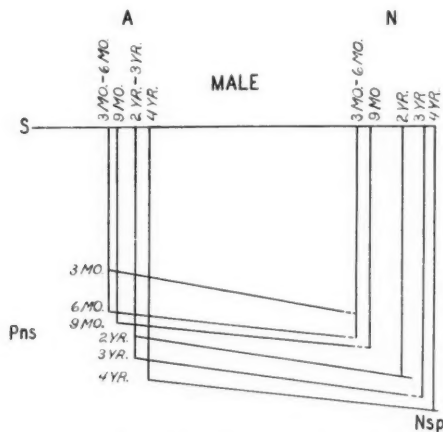


Fig. 3. Superimposed outlines of the nasal quadrilateral in white boys at the successive ages studied below 5 years, showing the general downward growth and forward drift. Lettering as in Fig. 1.

Superimposed outlines of the nasal quadrilateral at the successive ages studied are depicted in Fig. 3, which therefore illustrates the growth of the nasorespiratory area. The general downward growth and forward drift are sufficiently obvious in this diagrammatic representation.

THE STANDARD SERIES OF NORMAL GIRLS.

The dimensions of the nasorespiratory area in the twelve girls chosen as standards are shown in Table 2.

TABLE II.

DIMENSIONS OF THE NASORESPIRATORY AREA IN TWELVE WHITE
GIRLS CHOSEN AS STANDARDS.

Age	Length		Height	
	Roof (NS)	Floor (Nsp-Pns)	Anterior (NB)	Posterior (Pns-A)
3 months.....	46.5	35.5	27.5	23.0
6 months.....	49.0	36.5	29.5	23.5
9 months.....	50.0	36.5	30.0	24.0
2 years.....	59.0	42.0	36.0	30.0
3 years.....	64.0	43.5	39.0	32.5
5 years.....	64.0	45.0	40.0	35.5

Growth in the roof is progressive until the age of 3 years, and although growth of the floor continues until five years it is less vigorous than in the roof. During this period the roof has grown 17.5 mm., the floor only 9.5 mm. The gains are respectively 38 and 27 per cent.

Since the roof of the nose is also the floor of the anterior cranial fossa, its relative stability is a measure of the early attainment of cranial size, as stated by Todd and Tracy.² The floor of the nose, being also the hard palate, continues to increase in length

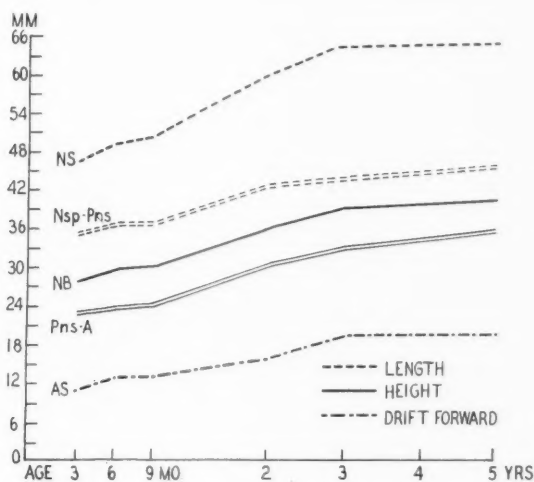


Fig. 4. Nasorespiratory area. Girls, under 5 years.

along with the dental arch, which extends to accommodate the permanent molars.

The growth in anterior height, like that of the roof, is fairly uniform until three years. On the contrary, posterior height shows a curve of increment comparable to that of the floor.

Both anterior and posterior height have gained 12.5 mm., but the gain for the former is 46, and that for the latter 54 per cent.

Fig. 4 plots the increments implied in Table 2. While these increments in general parallel those of the boys, they differ in not showing that early posterior vertical growth obvious in the boys between 3 and 9 months (Figs. 2 and 3).

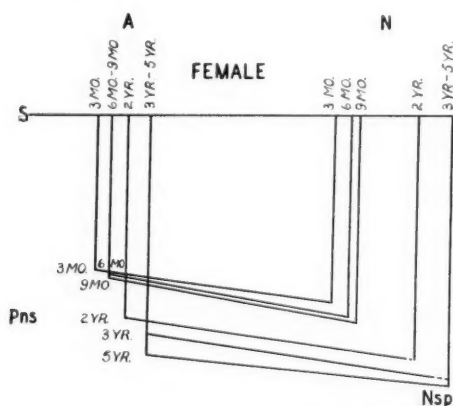


Fig. 5. Superimposed outlines of the nasal quadrilateral in white girls at the successive ages studied, below 5 years, showing less vertical growth but greater forward growth and drift. Lettering as in Fig. 1.

Fig. 5 shows the superimposed outlines of the nasal quadrilateral in our standard white girls. Comparing this with Fig. 3, it is plain that girls, in comparison with boys, show less vertical growth but greater forward growth and drift.

In Figs. 2, 3, 4 and 5 the dimension *AS* has been included, and the following measurements show practically similar increments in both sexes for the ages studied:

Age	Male	Female
3 months.....	13.0	11.0
6 months.....	13.0	13.0
9 months.....	14.0	13.0
2 years.....	17.0	15.5
3 years.....	17.0	19.0
4-5 years.....	19.0	19.0

Fundamentally the dimension AS is the measurement of a growth trend. Since the location of the point A is determined solely by the perpendicular to the cerebral floor (NS) from the hinder end of the palate (Pns), the forward movement of the point A is a measure of the forward movement of the entire nose under the brain case from the sella turcica (S). This forward drift is obscured somewhat by the anteroposterior growth in hard palate which accompanies the increase in alveolar growth to accommodate the permanent molar tooth buds.

It is apparent, therefore, that the entire nasorespiratory quadrilateral moves forward with growth and does so in keeping with the forward growth of NS . The forward extension of the upper face is both sphenoidal and ethmoidal (carrying the frontal with them).

The floor of the nasal area does not grow as fast as the roof. ✓
The hard palate moves forward with general facial drift, even while it is increasing in length. This has an important bearing on the opening up of nasopharynx. Todd² and Krogman¹ have demonstrated marked anteroposterior growth in body and great wing of sphenoid. This, together with the general basilar growth manifest in the basi-cranial axis of Huxley, results in a gradual opening of the nasopharynx, which keeps pace with forward sphenoidal growth.

The widening of the nasopharynx is a growth phenomenon achieved by two growth changes: expansion of the wings of the sphenoid and forward drift of the palate. It follows then, that failure of anteroposterior development of upper face results in a relative constriction of nasopharynx so that a pharyngeal tonsil, at the height of its lymphoid growth, may become an impediment to breathing.

ABERRANCIES IN NASORESPIRATORY GROWTH.

The discussion up to this point has centered about the normal proportionate growth of the nasorespiratory quadrilateral in physically fit and constitutionally healthy children studied by the Associated Foundations. In the course of the serial examination of a large group of children it is inevitable that examples of disordered growth and development occur. From these examples we have selected, for detailed study of this growth imbalance, the roentgenograms of sixteen female and seventeen male children from 3 months to 5 years of age. The measurements and proportions illustrated in Figs. 3 and 5 are utilized as standards on which to plot the aberrant examples.

In detailed analysis of the asymmetry any one of the four dimensions of the nasorespiratory quadrilateral may be normal by reference to our standards, retarded, or accelerated. There is possible, therefore, a rather wide range of variation.

Of the 68 dimensions recorded in 17 males, 10 are normal, 16 accelerated in growth, 42 retarded, namely 15, 23 and 62 per cent respectively. Of the 64 dimensions in the 16 females, 8 are normal, 12 are accelerated in growth, 44 are retarded, namely 12, 19 and 69 per cent respectively. In other words, the maladjusted growth is due principally to underdevelopment, expressed as failure in the increment of growth.

In the males failure of adequate growth affects particularly the height dimensions, but in the females the anteroposterior dimensions. It will be remembered that in boys posterior nasal height grows faster and girls nasal roof grows faster. Hence the most rapidly growing dimensions are hardest hit precisely as Todd and Wharton showed in the sheep.³ It is certainly not without significance that in every one of the female aberrancies, roof and floor have been retarded, and in every male either anterior height, posterior height or both have been retarded. This distinction likewise calls attention to the greater uniformity of growth pattern in the females as contrasted with the males because, on the whole, there is less disturbance of developmental growth in the face of girls at this age.

With but one exception, in this series of growth imbalances, general retardation in all dimensions is found only in the children

of about 3 years and over. The younger children show disharmonic growth focussed in one of the dimensions. If the general condition predisposing to disturbed growth persists through the third year all dimensions are affected and there is a more or less uniform retardation.

This observation is well illustrated by BS. 937 (Fig. 6), a boy, examined at 3 years 11 months and 4 years 7 months of age.

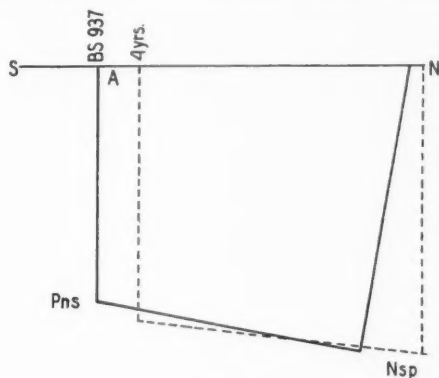


Fig. 6.

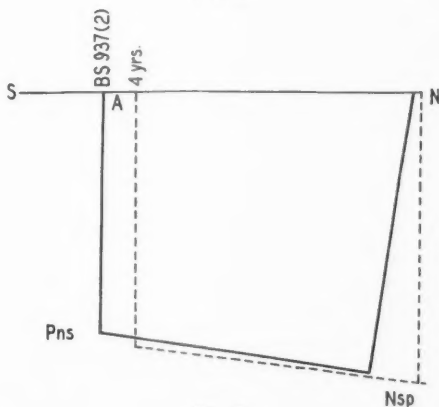


Fig. 7.

Figs. 6 and 7. The nasal quadrilateral of a boy BS. 937 (a), 3 years 11 months and (b) 4 years 7 months, superimposed upon the standard frames to show progressive disordered growth accompanying exuberant adenoid and tonsillar tissue requiring operation.

Tonsillectomy was performed at 3 years. At the earlier examination there is marked failure of anteroposterior development, especially in the floor, which is at the 3-6 month stage. Roof growth has progressed to the 2-3 year stage. Vertical growth is nearly normal, with only a slight retardation in posterior height. Eight months later there has been practically no growth. Floor is at the 9-month, roof at the 3-year stage, whereas anterior and posterior height have reached the 4-year stage. The retardation is now general.

In four of these boys the exuberant tonsillar and adenoid tissue was removed by operation. In each of these there was retarda-

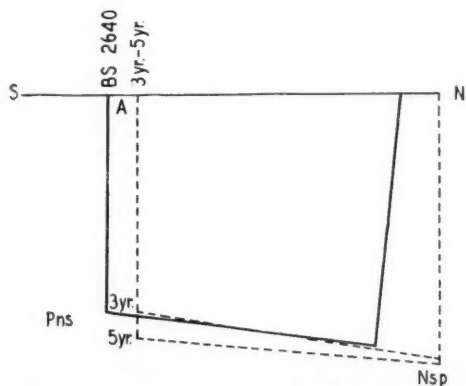


Fig. 8. Nasal quadrilateral of a girl, BS. 2640, 3 years 4 months of age, superimposed upon the standard frame to show disordered growth characteristic of girls. The anteroposterior dimension fails more significantly than the vertical.

tion in upper facial or nasorespiratory growth localized either in floor or in posterior height. In other words, the nasopharynx did not open up as it should have done.

Space forbids discussion of all examples, but a specially instructive one is BS. 2640, a girl of 3 years 4 months (Fig. 8), who showed an exuberant pharyngeal tonsil and a very small nasopharyngeal passage. The dimensions of the nasorespiratory area, plotted upon the female standards, demonstrate the disordered growth as a general retardation most pronounced in anteroposterior dimensions. Floor is at the 18-month stage and

roof at the 20-22 month stage. Forward growth of the entire upper face is markedly retarded. Posterior height is at 3 years and anterior height at about 34 months. There has therefore been retarded forward growth as well as retarded forward drift accompanying a hypertrophied pharyngeal tonsil. As a result, the nasopharyngeal passage is greatly narrowed.

There is an intimate relationship between nasorespiratory growth and size of the nasopharynx. Disproportionate growth is reflected in a relative constriction of the nasopharynx, which will be the more readily occluded by a large pharyngeal tonsil.

Two other children in our series must be mentioned as illustrating special features of this study.

Donald L. (BS. 2441), an habitual mouth breather, was reported to be suffering from frequent upper respiratory infections. The pediatrician, presuming the presence of adenoids, advised immediate operation. As the boy had been studied by the Associated Foundations on three different occasions, first at the age of 3 years, again at 3½ years and finally at 4 years, the last assessment being made just prior to the mother's seeking my advice concerning his condition, we referred to the roentgenograms for information. These showed absolutely no evidence of nasopharyngeal obstruction due to an obstructing pharyngeal tonsil but a definite failure in vertical growth (anterior and posterior height) and a marked lagging in the forward drift of the hard palate. This, however, is but one of the factors producing the clinical condition. The anteroposterior roentgenogram shows a nasal septum decidedly thickened along the vomer and flanked on each side by bulging turbinates, thus greatly reducing the nasal airways.

Obviously no help could be had from an adenoid operation, although unfortunately such a recourse is almost a standard procedure.

Our last illustration demonstrates the persistence of an aberrant pattern. Paul H. (BS. 2846), a boy, of 13 years, was referred for mouth breathing. Tonsils and adenoids had been removed at 4½ years, but the habit persisted. Clinical examination

showed neither sinus disease nor enlarged tonsils or adenoids. There was, however, a straight thick septum and large, hypertrophied, boggy turbinates, which almost occluded the nasal passages. The lateral roentgenogram revealed a wide nasopharynx unobstructed by lymphoid tissue and a marked retardation in the forward drift of the nasal quadrilateral indicating disharmonic growth in the nasorespiratory area. From the foregoing discussion it may be reasonably inferred that the pattern for this aberrancy was laid down in the patient's very early childhood.

NASORESPIRATORY DEVELOPMENT IN FACIAL GROWTH FROM
SIX TO EIGHTEEN YEARS.

The development of the nasorespiratory area after 5 years of age has been studied in 43 boys and 45 girls from 6 to 18 years of age. This material has been grouped in periods of two years, each period starting on the even year, as shown in Table 3. The children were chosen on the basis of good physical development and normal occlusion.

TABLE III.

DIMENSIONS OF THE NASORESPIRATORY AREA IN WHITE BOYS AND
GIRLS FROM SIX TO EIGHTEEN YEARS.

Age in years	Sex	No. in group	Length		Height		
			Roof (NS)	Floor (Nsp-Pns)	Anterior (NB)	Posterior (Pns-A)	(AS)
6.....	M	14	64.5	45.9	45.3	37.7	14.9
8.....	M	14	67.3	48.2	48.5	39.8	15.5
10.....	M	3	65.7	48.0	54.2	45.3	13.7
12.....	M	15	69.6	52.4	52.5	45.0	16.5
14.....	M	19	72.2	55.1	54.0	46.8	17.1
16.....	M	10	72.2	52.4	54.4	46.9	18.0
18.....	M	1	75.0	56.0	59.0	46.5	15.0
6.....	F	11	62.2	44.8	45.2	37.8	14.9
8.....	F	5	65.0	46.8	44.6	38.7	16.9
10.....	F	5	64.8	48.6	47.5	38.0	16.2
12.....	F	24	67.2	51.6	50.3	42.9	18.5
14.....	F	18	67.9	52.1	51.3	43.9	17.5
16.....	F	8	68.9	52.7	52.7	43.1	15.5
18.....	F	4	68.3	53.3	51.1	43.1	16.3

We have already noted that changes in proportion occur in the dimensions of the nasal quadrilateral up to 3 years, but thence-

forward dimensions increase though proportions remain unchanged.

In Table 3 and in Figs. 9 and 10 the development of the naso-respiratory area from 6 to 18 years has been expressed in summary form. There is approximately parallel extension of roof and floor, *NS* and *Nsp-Pns*, the growth rate of which appears to continue at a velocity similar to that between birth and 5 years. There is a similar approximate parallelism in growth rate of anterior and posterior nasal height, *NB* and *Pns-A*. After five years, for the first time, the absolute dimensions of anterior nasal height equal or exceed those of the floor, especially in the males.

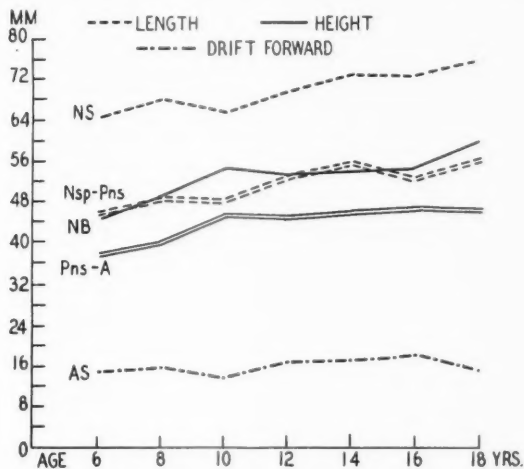


Fig. 9. Nasorespiratory area. Boys.

It is extremely difficult, on the basis of the material studied, to state periods of relative acceleration. In boys, nasal height seems to grow more vigorously between 8 and 10 years, and again after 16 years. In girls, there is a specially vigorous growth in nasal height between 10 and 14 years, beyond which age there is practically no further growth. In both sexes extension of roof and floor is relatively uniform during the entire growth period, though there is a slight acceleration in boys between 10 and 14 years.

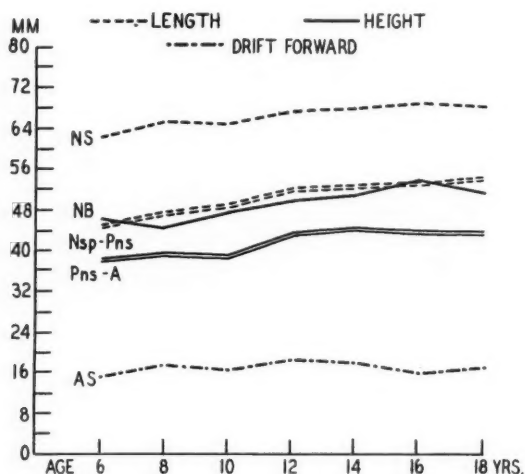


Fig. 10. Nasorespiratory area. Girls.

A point of interest in the opening up of the nasopharynx is the fact that *Nsp-Pns* is growing faster than *AS*; in other words, the hard palate increases in anteroposterior length more rapidly than the upper face drifts forward. This lengthening of the palate accompanies the alveolar extension required for the development of second and third permanent molars.

Nasofacial growth is a remarkably ordered phenomenon after the age of 5 years, provided the correct pattern has already been achieved. The period from birth to three years, at the minimum, or 5 years at the outside, is that in which aberrancies in nasofacial growth are to be expected.

SUMMARY.

1. This study of upper facial growth, with special reference to expansion of the nasorespiratory area, has been made possible by the accurate measuring device known as the Broadbent-Bolton roentgenographic cephalometer, which holds a child's head firmly in a predetermined position and ensures that on subsequent examinations the head will be held in identically the same position.

2. The study has been conducted upon twenty-six boys and twenty-eight girls between 3 months and 5 years of age, and upon forty-three boys and forty-five girls between 6 and 19 years of age. Each child was examined at least twice at an interval of three months to one year, depending upon the age.

3. Collateral studies ensured that the children comprised in this survey were of average physical growth and development for their age.

4. The younger series showed little difference in the character of growth in boys and girls under 5 years. Anteroposterior growth of the upper face is earlier in girls and vertical growth greater in boys.

5. In cranial and facial growth the entire nasal skeleton drifts forward with growth of the cranium, thus enlarging the nasopharyngeal area at an early age.

6. Disturbances of growth are divisible into two types. In one a normally grown nose fails to drift forward through failure of forward expansion of the cranium. In the other a forwardly drifting nasal skeleton itself shows disharmonic growth in its several dimensions.

7. Disordered upper facial growth accompanies pharyngeal tonsil hypertrophy, though the nature of the relation between the two conditions is not yet clarified.

8. Already by the age of 5 years the pattern of upper facial development is established. Defects of growth originate, therefore, in early childhood and persist throughout life.

9. In later childhood and adolescence no further modification in proportions of the growing nose takes place. It is to be observed, however, that female growth has practically ceased at 14 years, though there is an adolescent vertical growth in boys of 16 to 18 years.

10. Further investigation on the relation between upper facial growth and respiratory obstruction, whether of the nasal or nasopharyngeal type, would be very fruitful; so also would a detailed analysis of facial growth in relation to constitutional health in young children.

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XXXVIII.
THE PREVENTION AND TREATMENT OF
DEAFNESS.*

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The social and economic handicap of severe deafness and the frequency of this affliction make the prevention and treatment of deafness a most important problem of medicine. How far have we progressed toward solving this problem?

The possibilities of prevention and cure depend *a priori* upon the causes of deafness, and as the result of studies carried out the past few years we have some additional facts concerning the etiology of deafness. An extensive study of severe deafness in childhood was carried out several years ago under the auspices of the National Research Council.¹ More than 5,000 children in our public institutions for the deaf were examined with an effort to determine the cause of the defect in each case. The results of this study were very illuminating and are summarized in Chart I. Sixty per cent of the children in the state schools for the deaf were born with their affliction and a third of these gave a family history of deafness, while 7 per cent were the result of consanguinous marriages. Forty per cent of the children acquired their deafness, the loss of hearing occurring abruptly, usually during a severe attack of cerebrospinal meningitis, measles, scarlet fever, pneumonia, influenza or whooping cough. In meningitis a suppurative invasion of the labyrinths through the internal auditory meatus often causes total loss of hearing, but in the other infectious diseases profound deafness is nearly always due to a toxic neuritis of the nerve of hearing rather than to an associated otitis media. We see, then, that profound deafness in childhood is congenital or acquired, about half and half. When acquired it is

¹Read before the Rock River Valley Eye, Ear, Nose and Throat Society, November 21, 1933.

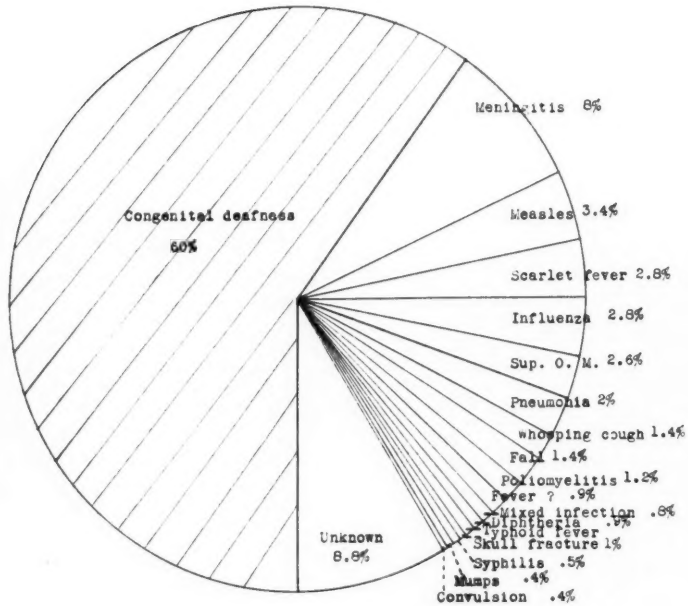


Chart 1. Causes of profound deafness in childhood (based on a study of 5348 children).

usually the result of a toxic neuritis during an acute infectious disease resulting in a profound primary nerve deafness.

The past year we have been carrying out a similar study of severe deafness in adults.² In order to obtain accurate, unbiased statistics we examined members of the Chicago, and Washington (D. C.) Leagues for the Hard of Hearing. These are adults who suffer from deafness severe enough to constitute a serious social or economic handicap. A detailed history of the deafness was obtained from each person followed by a complete ear, nose and throat examination with the tuning fork hearing tests so that in nearly every case a definite diagnosis could be made and the cause of the deafness determined.

The results of this study of severe deafness in 165 unselected adults were significant. Eighty-two per cent showed the reactions

of conduction deafness while 18 per cent had primary nerve deafness.

Of those adults suffering from primary nerve deafness only two were born deaf; five had acquired their nerve deafness during an acute infectious disease as the result of a toxic neuritis of the nerve of hearing; one, apparently, had syphilitic nerve deafness; two were deaf from noisy occupations, and seven suffered from senile nerve deafness. In the remaining twelve, the cause was unknown, but several of these gave a strong family history of progressive deafness and may have had the labyrinthine type of otosclerosis, while focal infection may have been a factor in some.

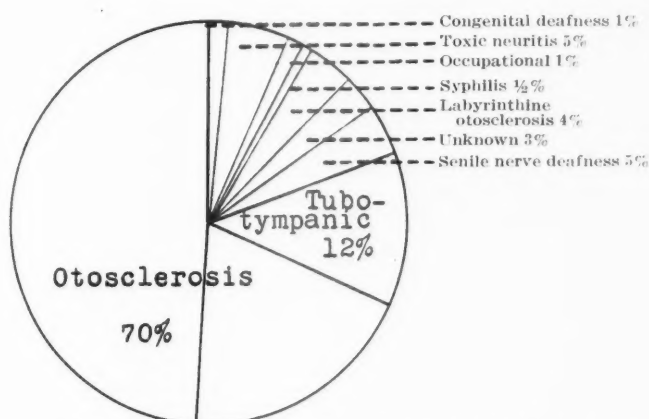


Chart 2. Etiology of deafness in 165 severely deafened adults.

Eighty-two per cent of these severely deafened adults showed the conduction form of deafness. A fourth of this group had chronic catarrhal otitis media, usually with a history of previous chronic discharging ears. The remainder, 70 per cent of all the adults examined, had otosclerosis with primary stapes fixation. (Chart 2.) This is a very high percentage of otosclerosis. How did we make the diagnosis of otosclerosis in so many cases? All of these patients suffered from conduction deafness. The Schwabach test was prolonged, the Rinne test was negative, and the low

tones were impaired more than the high notes. In other words, all these patients had Bezold's triad for conduction deafness. Bezold stated that when this triad was found in the presence of normal drum membranes, the patient suffers from otosclerosis. About two-thirds of these patients had one or both drum membranes normal, and in a patient bilaterally deaf one normal drum membrane has the same significance as two.

In addition, all of these patients diagnosed otosclerosis suffered from progressive deafness, which came on insidiously, nearly always in early adult life, and usually with no antecedent history of middle ear trouble. In our experience chronic catarrhal otitis media is not progressive, except in those cases where there are recurrent attacks of acute tubal occlusion.

The fact must not be overlooked that we obtained in 73 per cent of our cases diagnosed otosclerosis a family history not of deafness alone, but of progressive deafness, which came on insidiously in early adult life and was, therefore, probably otosclerosis.

A third of the cases diagnosed otosclerosis showed slight changes in both drum membranes, consisting of slight mottling, thickening or loss of luster. These changes are the result of tubal catarrh in childhood. Many of these patients remembered having had earaches or attacks of acute otitis media as a child, but in every instance the hearing returned to normal for a period of years at puberty before the insidious onset of progressive deafness. Any group of adults with normal hearing will show slight changes in the drum membranes in about the same percentage of cases. There was no evidence whatever in any of these cases of otosclerosis with slight drum membrane changes that there had been any active tubal catarrh during the course of the progressive deafness.

What about chronic sinusitis or nasal pathology in these 165 severely deafened adults? One patient with chronic otitis media due to cholesteatoma formation had a chronic maxillary sinusitis; another patient with chronic otitis media had an atrophic rhinitis with crusting. One hundred and sixty-three of the 165 adults had no symptoms or clinical findings of chronic sinusitis or of nasal pathology.

What are the causes of mild degrees of deafness? Impacted cerumen is the easiest to cure. The most frequent cause is tubal occlusion, usually occurring in children and usually associated with adenoids. However, acute tubal occlusion does occur in adults and is apt to be overlooked unless an examination of the drum membranes is made by one who is accustomed to seeing this condition. The patient is deaf with fullness in the ears and tinnitus, usually following an upper respiratory infection—a head cold or a pneumonia. Examination shows the drum membranes acutely retracted, abnormally transparent like a piece of tissue paper with oil on it, and with the hyperemic, reddened mucosa of the middle ear shining through. A yellowish tinge, or sometimes bubbles or a fluid level may be visible. If inflations for a few days do not promptly relieve the condition, a paracentesis of the drum membranes, without anesthesia, will allow a large amount of thin, yellow mucoserum to be blown out and the hearing will be dramatically restored.

The rôle of chronic catarrhal otitis media in the causation of progressive deafness has been confused in many of the otologic textbooks. In the first place, the deafness and the drum membrane changes in chronic catarrhal otitis media are the residue of recurrent or long standing acute tubal occlusion which usually occurred in childhood. They are residues, and the process is not progressive unless there are renewed attacks of acute tubal occlusion. A proportion of mild deafness in adult life is due to these residues. Because the process is not progressive the patients rarely consult a doctor for the slight defect. There are an equally large number of adults showing the drum membrane changes of chronic catarrhal otitis media but with perfectly normal hearing. In fact, the majority of childhood tubal catarrh which is so common not only clears up at puberty when the lymphoid tissue in the nasopharynx undergoes atrophy, but the hearing, more often than not, returns to normal. In only a small percentage has the process caused enough permanent damage to lead to severe deafness in adult life, and in most of these there have been, in addition, recurrent or chronic discharging ears.

In the second place, because the changes in chronic catarrhal otitis media are residues of an exhausted process, treatment dur-

ing this quiescent stage is useless. A preliminary series of perhaps a half dozen inflations is justified, and if there is no demonstrable improvement they should not be persisted in. Prolonged and repeated inflations lead to abnormal relaxation of the drum membrane and may eventually further impair the hearing.

The point of view expressed here is at variance with that currently held by many otologists. However, careful clinical observation of these patients over a period of years will bear out the facts that catarrhal changes alone are rarely responsible for severe defects in the hearing, that the changes seen in the drum membranes of many cases of progressive deafness are residues of a childhood process and have nothing to do with the progressive deafness, and that chronic catarrhal otitis media is in itself not progressive. Another point which should be emphasized is that all cases of long standing conduction deafness are associated with more or less secondary nerve degeneration. For example, a case of chronic suppurative otitis media will always show a certain degree of nerve deafness. This nerve deafness, however, is not due to a second or superimposed etiologic factor, and to refer to these cases as mixed deafness, or combined deafness, may be confusing and inaccurate. Actual instances of combined deafness, where there is more than one etiologic factor, are rare. We found a combined etiology in only five of the 165 adults examined.

Chart III represents graphically the causes of deafness with their relative importance. With this knowledge of the etiology of deafness as a basis, what are the possibilities of prevention and treatment?

Notice that at birth there are a certain number of congenitally deaf children. (Chart III, 1.) This form of profound deafness accounts for 60 per cent of the children in our state schools for the deaf. No treatment can restore this anatomic malformation of the organ of Corti.

Soon after birth, the severe general infections, particularly measles and scarlet fever, begin to exact their toll of toxic neuritis of the eighth nerve. (Chart III, 2.) This cause for severe deafness accounts for 40 per cent of the children in our state schools for the deaf. While deafness occasionally occurs in adults

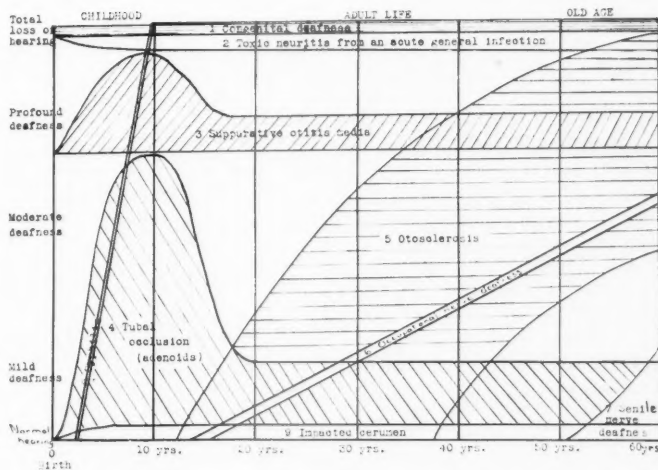


Chart 3. Diagram showing relative importance of the various causes of deafness at the different age periods. The vertical line represents the severity of the defect in hearing, the horizontal line the age of the patient. Notice that middle ear disease is largely responsible for deafness in childhood; otosclerosis is the great cause for progressive deafness in adult life, while senile nerve deafness accounts for deafness coming on in old age. Syphilis causes a rapid loss of hearing, usually in children as the result of congenital syphilis (but sometimes in adults with acquired syphilis), while occupational nerve deafness begins at puberty when the noisy occupations are undertaken and progresses in a similar manner to otosclerosis.

as the result of a toxic neuritis of the acoustic nerve, especially following influenza, pneumonia and typhoid fever, the majority of this form of deafness comes on during the first five years of life. Prevention lies in protecting young children from the exanthemata for as long as possible. To expose a small child to measles "to get it over with" may mean the sacrifice of its hearing, since older children are less susceptible to this toxic neuritis of the nerve of hearing. There is often some spontaneous recovery from the defect in hearing following the acute illness, but treatment cannot hasten or augment this recovery.

Suppurative otitis media, acute and chronic, also begin to be an important cause for deafness soon after birth and they reach their highest incidence in midchildhood. (Chart III, 3.) A single

attack of acute otitis media usually causes only a temporary deafness, but repeated attacks of acute otitis media, and particularly a chronic running ear result in a progressive loss of hearing which may continue as long as the ears discharge. Approximately 10 per cent of severe deafness in adult life is the result of suppurating ears in childhood. Early and adequate treatment will largely prevent this cause for deafness. Chronic discharging ears should always receive treatment until the ears are dry.

There are two distinct types of chronic suppurative otitis media. One is easy to treat, is not a menace to life, and is apt to recur with each head cold. This is the type associated with a central perforation. The disease is in the mucosa of the middle ear and eustachian tube. The discharge is mucous. At first it may be foul, due to saprophytic infection, but after one careful cleansing or the use of an antiseptic like boric alcohol, the odor disappears. This type is often due to enlarged adenoids and clears up when the adenoids are removed. If not, a few cleansings and the use of boric powder or Sulzberger's boriodin powder will usually give a dry ear.

The second type of chronic suppurative otitis media is the bone-involving type, usually due to cholesteatoma formation. The perforation is marginal with erosion of part of the annulus and involvement of Shrapnell's membrane. The skin from the external canal has grown in and lined the attic and sometimes the aditus and antrum. The constantly desquamating squamous epithelium causes the accumulation of cheesy masses of epithelial debris with a foul odor. The bone is gradually eroded around the cholesteatoma so that life may be endangered. Even after antiseptics and careful, repeated cleansing, a foul odor may persist. The treatment of cholesteatoma consists in keeping the epithelial-lined cavity clean. If this cavity is confined to the attic, irrigations with the attic cannula at intervals will be all that is necessary. If the cavity is so large and the perforation so small that repeated irrigations fail to give a dry ear, a radical mastoidectomy may be indicated.

The purpose of this operation is to convert the cholesteatoma cavity into a common cavity with the external auditory canal.

This is done by removing the posterior and superior canal wall. In most of these patients the incus and a large part of the drum membrane have been destroyed by the cholesteatoma. Where the radical mastoid operation is really indicated the hearing will usually, therefore, not be impaired and is often improved. The use of a skin graft to hasten epidermization of the radical cavity will minimize scar tissue formation and help to preserve the hearing.

The most frequent cause for deafness in childhood is acute tubal occlusion, usually due to adenoids. (Chart III, 4.) The adenoids reach their largest size in midchildhood and nearly 10 per cent of all school children suffer from this form of deafness at one time or another. At puberty most of these cases of mild degrees of deafness clear up spontaneously with the atrophy of lymphoid tissue in the nasopharynx, but a residue of mild deafness persists in a few cases and an occasional case of severe deafness results from prolonged tubal catarrh. In adult life, a few new cases of deafness from tubal occlusion occur and this may be the first symptom of a carcinoma of the nasopharynx. After ruling out adenoids or a tumor of the nasopharynx, treatment consists in inflations of the middle ears. If fluid in the tympanic cavity persists, a paracentesis is indicated.

Syphilis causes a very few cases of profound deafness. (Chart III, 8.) Treatment is not satisfactory once the deafness has begun. Arsenic must be avoided in luetic deafness, since it seems to hasten the loss of hearing.

Occupational nerve deafness is seen in riveters, boilermakers and others who work near very loud, high pitched noises. This accounts for only about 1 per cent of severe adult deafness. (Chart III, 6.) It can be prevented or arrested if recognized.

Senile nerve deafness begins to be evidenced in everyone by the age of 50 by loss of perception for the very high pitched notes. (Chart III, 7.) It comes on more rapidly in some families than in others; it is progressive and can neither be prevented nor helped by treatment.

We come finally to otosclerosis. This peculiar disease process consists of a spongifying of the ivory-like bone of the labyrinthine capsule and usually begins just anterior to the oval window close

to the footplate of the stapes. Clinical evidence of the insidious onset of very slowly progressive conduction deafness begins when this spongifying process encroaches upon the oval window and footplate of the stapes. This results, eventually, in complete fixation of the stapes by bony ankylosis. Sometimes the process does not involve the region of the oval window but causes a gradual involvement of the labyrinth resulting in primary nerve deafness. This is known as the labyrinthine type of otosclerosis. The symptoms of otosclerosis usually begin at or soon after puberty, but may first be noticed as late as 40. As the result of pathologic studies of temporal bones we now know that this disease is very common. Otosclerosis accounts for the majority of severe adult deafness.

What can we do for otosclerosis? The pathologic changes in otosclerosis are of a permanent, irreversible nature and we have no way of retarding or in any way altering the gradual progression of these pathologic changes. We must, accordingly, make it absolutely clear to the patient that he cannot expect to have his hearing improved by us or by any treatment. He must realize that a permanent change has occurred. In our study of members of the Leagues for the Hard of Hearing we were repeatedly impressed by the number of different treatments which these people had tried. In every case the same story was told. During the treatments, whatever their nature, the hearing seemed to be better, but after a few months had elapsed the patient again realized that the improvement had been only apparent and that actually the progressive loss of hearing had continued unabated. Only two of the 115 adults diagnosed otosclerosis felt that treatments had ever helped them in any way. Both of these patients had typical early otosclerosis and both were taking treatments at the time. One was having osteopathic adjustments of the cervical spine and was belligerently certain she heard better; the other was having inflations of the eustachian tubes, although his drum membranes and tubes were quite normal. More than half the patients had had operations on the nose and throat carried out to help the hearing and, of course, to no avail.

One patient, for example, was examined twenty years ago in the early stages of her deafness, when a definite diagnosis was

made of otosclerosis with beginning stapes fixation. She was advised to spend no money on local treatments. Since that time she has spent approximately \$5,000 on treatments to improve her hearing. She has had not one but several nasal operations, though her nose was normal when first seen, twenty years ago, and never gave her trouble. She has had massage of the ear drums and repeated inflations, with bouginage of the eustachian tubes. She states now that none of the treatments seem to have had any effect on the progress of the disease, though while she was taking each treatment she was hopeful that her hearing was a little better. She is now profoundly deaf with a marked conduction defect and beginning secondary nerve degeneration. Both drum membranes and both eustachian tubes were perfectly normal twenty years ago and are normal today.

The question of marriage and pregnancy will often arise. Two otosclerotics should certainly not marry and have children, because in our experience all the children of such a union will develop otosclerosis. A small percentage of women, about 20 per cent, have an appreciable, permanent increase in their deafness from pregnancy. In some cases there is a temporary increase, but followed, after delivery, by recovery to the former status.

Finally, we must help these patients with otosclerosis make the difficult but very necessary adjustments to their handicap. The very excellent paper on "The Psychology of Progressive Deafness," by Dr. Gordon Berry,² is very helpful. Lip reading should be learned early, electrical hearing aids should be prescribed when indicated, and contact with the Leagues for the Hard of Hearing should be made.

SUMMARY.

1. Profound deafness in childhood is half congenital, half acquired. Treatment cannot improve the hearing, but many of the acquired cases could be prevented by protecting young children from the acute infectious diseases.

2. Mild deafness in childhood is usually due to catarrhal otitis media and can be relieved by treatment.

3. Mild degrees of deafness in adult life may be the residue of childhood tubal catarrh. This type of defect is not progressive.

Active tubal occlusion occasionally occurs in adult life and can be relieved by treatments.

4. Chronic running ears account for 10 per cent of severe adult deafness and this 10 per cent is largely preventable by early and adequate treatment. Chronic aural discharge should always receive treatment until the ears are dry.

5. Otosclerosis causes 70 per cent of severe adult deafness and can neither be prevented nor helped in the present state of our knowledge.

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INNERVATION OF THE LARYNX: IV. AN ANALYSIS
OF SEMON'S LAW.*

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In 1881, Semon¹ formulated his well known law stating that in incomplete or partial recurrent laryngeal nerve paralysis there is an isolated paralysis of the abductor function of the glottis. This proclivity to disease of the abductor over the adductor muscles had been observed before (Rosenbach²), but Semon was the first to establish it on a firm clinical basis. Repeated observations have confirmed this law, and it has been quite generally accepted by laryngologists.

Recently, however, there has been a growing doubt as to its validity. Terracol³ has expressed this in his review of present day concepts concerning laryngeal innervation. New and Childrey⁴ were unable to find a single case obeying Semon's law among 217 cases of vocal cord paralysis. Smith, Lambert and Wallace⁵, in a survey of 235 cases of recurrent laryngeal nerve paralysis, found only one case which followed Semon's law.

These conclusions are based on the clinical observation that a paralyzed vocal cord rarely changes from a midline to a cadaveric position. The authors have assumed erroneously that such a transition should take place if Semon's law were true. In other words, they imply that a median or midline position means isolated abductor paralysis, while a cadaveric position indicates complete recurrent nerve paralysis. This is contradictory to statements in their respective papers that complete recurrent laryngeal nerve paralysis may give rise to either a cadaveric or a median position.

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Although these clinical aspects of the problem will be discussed, the main concern of the paper is with Semon's primary premise of the proclivity to disease of the abductor over the adductor function of the glottis.

THEORIES ATTEMPTING TO EXPLAIN SEMON'S LAW.

1. Felix Semon: There is a physiologic weakness of the muscles, nerves and centers subserving the function of abduction.
2. Morell Mackenzie: The abductor nerve fibers are situated in the periphery of recurrent laryngeal nerve where they are affected first by any noxious process.
3. Donaldson: Pressure on the recurrent nerve stimulates the abductor fibers first and wears them out, leaving the adductor fibers intact.
4. Grabower: The nerve endings in the adductor muscles are more complicated.
5. Sir David Ferrier: The abductor muscles are like other extensor muscles in the rest of the body, and are more susceptible to trauma and disease than flexor or adductor muscles.
6. Lermoyez: Inferior number and power of abductor fibers.
7. Leiri: A preliminary paralysis of the sensory fibers, which are more susceptible to trauma and disease, breaking up the reflex giving rise to abductor tension.
8. Negus: The abductor muscles are of later phylogenetic development than the adductor muscles and are biologically different.

THE PROBLEM.

Without discussing the above theories, the problem seems to resolve itself into a question of abduction versus adduction. The fundamental differences between these two functions of the glottis might be considered under the following headings:

- I. Centers for abduction and adduction in the central nervous system.
 1. Cortex.
 2. Brain stem.

- II. Abductor and adductor fibers in the recurrent laryngeal nerve.
 1. Quantitative differences.
 - a. Arrangement of fibers.
 - b. Number of fibers.
 2. Qualitative differences.
 - a. Type of fibers.
 - b. Conductivity of fibers.
- III. Difference in abductor and adductor muscles of the glottis.
 1. Quantitative.
 2. Qualitative.
- IV. Phylogenetic and ontogenetic considerations of adduction and abduction.
- V. Comment and clinical aspects of the problem.

Before examining the centers, nerves and muscles separately, however, it might be well to remember that in the living organism they are intimately integrated and do not act individually but as a biologic unity. For example, Chauchard and Dumont⁶ have shown that in the dog ablation of the laryngeal center in the cortex on one side increases the excitability of the recurrent nerve on the opposite side.

CENTERS FOR ABDUCTION AND ADDUCTION IN THE CENTRAL NERVOUS SYSTEM.

There are very few recorded clinical observations on the laryngeal centers in the brain. Obviously, however, voluntary speech, coughing and swallowing give rise to adduction, while voluntary inspiration leads to abduction. Garel and Dor⁷ reported two cases and Dejerine⁸ two cases of complete paralysis of one cord with no lesion except that of the cortex on the opposite side. It is probable that these observations are in error, however, as all other evidence indicates that both cords are innervated by the same centers. Semon⁹ examined many cases of aphasia and could find no paralysis of the cords.

Evidence presented by Onodi¹⁰ indicates that the cortical laryngeal centers in both man and animals act through lower lying involuntary centers in the brain stem. Anencephalic monstrosities or infants having had craniotomies preserved an ability to cry

and whine as long as the brain was intact to the level of the corpora quadrigemina. If the brain was destroyed below this level, all vocalization ceased. These observations were confirmed in dogs. The center for respiration or abduction was situated lower near the vagus nucleus.

Krause¹¹ found that stimulation of the prefrontal gyrus of the cortex in the dog on either side caused adduction of both vocal cords with the left cortex dominating. Ablation of the cortical centers stopped barking, which is apparently voluntary and analogous to speech in man. Such involuntary vocalizations as whining and growling were left intact until the medulla was sectioned. Semon and Horsley¹² found only an adductor center in the monkey's cortex but both adductor and abductor centers in the dog and cat. Russell¹³ was also able to demonstrate an abductor center as well as an adductor cortical center in the dog. Katzenstein¹⁴ showed that cortical stimulation in the dog may cause asphyxia and that the adductor center was stronger than the abductor center. In the cat, cortical stimulation gave abduction. He explained this by Mink's¹⁵ observation that a cat breathes twenty to thirty times a minute, while a dog breathes only from fifteen to twenty-five times a minute, and the possibility that abduction is physiologically stronger in the cat. He found that occasionally a weak current in dogs would give abduction but that, in general, this function was repressed in the cortex by adduction.

My own experiments with dogs agree with those of Katzenstein's. I do not know of any experiments dealing with the comparative strength of abductor and adductor centers in the brain stem. The fact that, in terminal states, respiratory abduction persists after reflex adduction or coughing is lost, however, indicates that in the brain stem abduction is strongest. All of the above observations suggest that the central nervous system is relatively unimportant as regards Semon's law except, perhaps, in rare lesions involving the abductor or adductor centers themselves.

ABDUCTOR AND ADDUCTOR FIBERS IN THE RECURRENT LARYNGEAL NERVE.

That the cause for Semon's law lies in the recurrent laryngeal nerve is to be expected, as this is where the trauma is usually

inflicted. If the recurrent nerve in dogs is sectioned so as to be separated from the central nervous system, the conditions still exist for Semon's law. Russell¹⁶ and others agree that abduction is lost first progressively towards the larynx as the death of the nerve proceeds from the point of sectioning. Dumont¹⁷ has shown that in dogs the chronaxia of the adductor fibers of the recurrent nerve is greater than that of the abductor fibers, indicating that the latter are more excitable and less resistant to trauma.

Jeanselme and Lermoyez¹⁸ have observed that postmortem in human beings the posterior crico-arytenoid muscle ceases to respond to direct stimulation, and stimulation of the recurrent

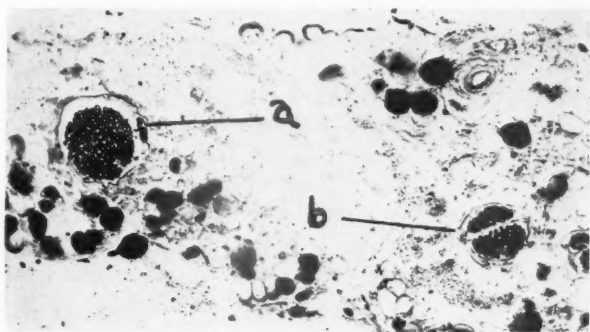


Fig. 1. Osmic acid stained cross section of recurrent laryngeal nerve showing (a) fibers going to posterior crico-arytenoid muscle and (b) smaller fibers going to lateral crico-arytenoid muscle.

nerve, before the other muscles of the larynx. Where the recurrent nerve has been sutured after section¹⁹ or after trauma²⁰ the adductor function returns before the abductor. This agrees with what happens experimentally in dogs²¹ where the first function to return after complete paralysis has been induced is adduction. The above observations show that the adductor fibers have a greater biologic resistance than the abductor fibers.

A more detailed examination of the fibers themselves (Fig. 1) shows that in dogs the abductor fibers are larger than the adductor fibers. According to Göthlin²² and Gerard,²³ large fibers are more excitable and have a lower threshold of stimulation than small

fibers. It might be concluded from the above data that large fibers are also more subject to trauma than small fibers. This would be in keeping with the neurologic principle that the more excitable a nerve, the less resistant it is to trauma. Measurement of the muscle fibers supplied by the large nerve fibers—the posterior crico-arytenoid muscle—shows that they average 30μ while the other muscle fibers of the larynx average 25μ . This, again, is in keeping with neurologic principles, for Hay²⁴ has demonstrated in rabbits that the size of the nerve fibers is in direct proportion to the size of the muscle fibers innervated.

Quantitatively, there is no anatomic basis for believing that the abductor fibers are situated peripherally where they would be affected first by a noxious agent. The theory that abduction is lost first because of the inferior number of abductor fibers can easily be disproved. Observations on peripheral branches where adductor and abductor fibers run separately show the same proclivity to disease of the later fibers as in the combined recurrent trunk.

DIFFERENCE IN ADDUCTOR AND ABDUCTOR MUSCLES OF THE GLOTTIS.

We come now to the possible differences in the muscles themselves—that is, the abductor or posterior crico-arytenoid as contrasted to the adductors or lateral crico-arytenoid, thyro-arytenoid, interarytenoid, and cricothyroid muscles. If the larynx is extracted experimentally in dogs, the death of the muscles as determined by direct electrical stimulation proceeds as follows:

Order of loss of function after death:

1. Posterior crico-arytenoid
2. Cricothyroid
3. Thyro-arytenoid
4. Interarytenoid
5. Lateral crico-arytenoid

This agrees with Semon and Horsley's²⁵ experimental findings and Barwell's²⁶ clinical observations.

It is obvious that the muscles themselves obey Semon's law. A more detailed examination of the muscle fibers themselves might give us a better understanding of the biologic factors involved. According to Fulton,²⁷ the abductor or posterior crico-arytenoid muscle is a pure white muscle, while the adductor mus-

cles are pure red muscles. Fulton's conclusions, however, are based on criteria which no longer are acceptable. Denny-Brown²⁸ believes that red and white muscles can be differentiated not by the size of the fiber or the speed of contraction, but by the number of lipid granules contained. These granules give the muscle its color, while the protein content determines the size of the fibers. According to Denny-Brown, all muscles are red at birth and contain these lipid granules which may disappear either in the natural differentiation of white muscles during growth or in markedly emaciated states.

By using Ewald's²⁹ stain to demonstrate these lipid granules the percentage of red fibers in each laryngeal muscle of the adult dog was found to be as follows (Fig. 2):

Muscle	Percentage of Red Fibers
A. Posterior crico-arytenoid	95 per cent
B. Cricothyroid	75 per cent
C. Thyro-arytenoid	10 per cent
D. Lateral crico-arytenoid.....	0 per cent
E. Interarytenoid	0 per cent

In agreement with Denny-Brown, all of the laryngeal muscles in dogs under 2 months contained lipid granules—i. e., were red muscles. At the age of 2 months there is evidence of a beginning differentiation of white fibers as indicated by an absence of granules in some of the fibers of the adductor muscles (Fig. 3). As the dog grows older, the adductor muscles lose more and more granules till in the adult some of these muscles contain no granules at all—i. e., they become white muscles. This differentiation of the adductor muscles is undoubtedly in some way associated with the specialization of adduction for vocalization.

The best way to study quantitatively the comparative strength of the adductor as opposed to the abductor muscles is by stimulation of the recurrent nerve. In dogs under 2 months abduction is always obtained, while in dogs over 4 months adduction is always obtained. It is, therefore, obvious that in young dogs the abductors are stronger, and in adult dogs the adductors are stronger, a fact which is easily correlated with the specialization of the adductors in adult dogs as noted above.

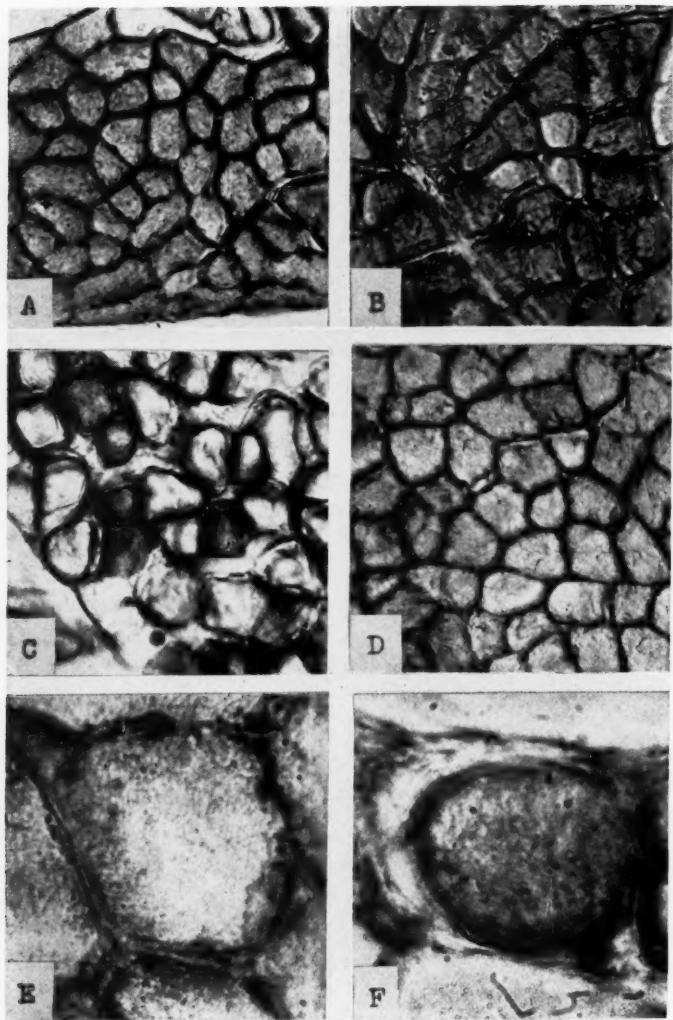


Fig. 2. Ewald-stained cross sections of the laryngeal muscles in an adult dog. *A*, posterior crico-arytenoid muscle, 95 per cent red fibers. *B*, cricothyroid muscle, 75 per cent red fibers. *C*, thyro-arytenoid muscle, 10 per cent red fibers. *D*, lateral crico-arytenoid muscle, no red fibers. *E*, detail of a white fiber in the lateral crico-arytenoid muscle. *F*, detail of a red fiber in the posterior crico-arytenoid muscle.

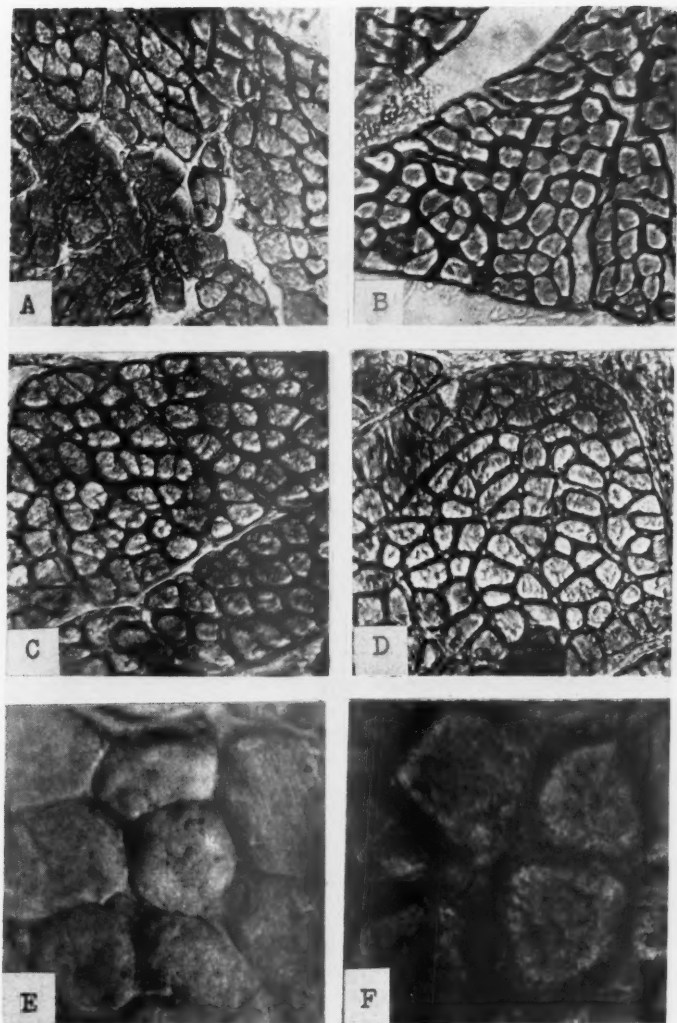


Fig. 3. Ewald-stained cross sections of the laryngeal muscles in a 2-months-old dog. *A*, posterior crico-arytenoid muscle. *B*, cricothyroid muscle. *C*, thyro-arytenoid muscle. *D*, lateral crico-arytenoid muscle. *E*, detail of a white fiber in the lateral crico-arytenoid muscle. *F*, detail of a red fiber in the posterior crico-arytenoid muscle. Practically all the fibers contain lipoid granules and are red fibers. There are a few fibers, however, in the adductor muscles that have lost their granules and have become white fibers.

The differential effect of ether on abduction and adduction at different ages has been a matter of interest to many investigators. Hooper³⁰ observed that stimulation of the recurrent nerve in dogs gave adduction with light ether narcosis and abduction with deep ether. Semon and Horsley,²⁵ on the other hand, believed that ether depressed abduction more than adduction. This agrees with my own findings which are that under 2 months abduction is always obtained, while in dogs over 4 months adduction is always obtained in spite of the depth of narcosis. At 2 months adduction occurs only under deep ether, while at 3 months adduction is obtained with lighter ether. This indicates that ether has a selective effect on the abductors, which fits in with the fact that the abductors contain more lipoid granules than the adductors. Theoretically, according to the Meyer-Overton law, one would expect these lipoid granules to be affected first by ether, which seems to be true.

In adult human beings stimulation of the recurrent nerve through the skin gives adduction as shown by Hooper.³⁰ Although the reaction to stimulation of the recurrent nerve in human infants is not known, there is evidence that abduction might be the more powerful. Gougenheim and Lermoyez³¹ have measured the glottis in infants and adults, and found that the respiratory diameter is greater than the vocal diameter in the former, while in adults the reverse is true. In other words, infants' larynges are built primarily for respiration and adults' for vocalization.

PHYLOGENETIC AND ONTOGENETIC CONSIDERATIONS OF ADDUCTION AND ABDUCTION.

Negus³² has made an extensive study of the development of the larynx in a great many species of animals, from the lowest to the highest forms. He finds that the first evidence of a larynx occurs in a lower form of lung fish. This primitive larynx consists simply of a sphincter muscle surrounding the origin of the rudimentary trachea from the esophagus. Constriction protects the lung from food, and dilation is brought about by relaxation of the sphincter. In higher forms of lung fish dilation is assisted by a group of fibers which pass laterally from each side of the sphincter muscle. In higher forms of animal life these dilator fibers

become the posterior crico-arytenoid muscles, while the sphincter muscle splits up into the adductor muscles, excluding the crico-thyroid, which arises from the pharyngoconstrictors. Negus concludes that the primary function of the glottis is adduction, while abduction is secondary. He thinks that this is strong biologic evidence in support of Semon's law.

Embryologic studies by Kanthack,³³ Nicolas,³⁴ Soulie and Bardier,³⁵ and Lissner³⁶ show that the posterior crico-arytenoid develops separately from the adductor muscles, which develop more or less in relation to one another. These observations further support the theory that the posterior crico-arytenoid is fundamentally different from the adductor muscles.

COMMENT AND CLINICAL ASPECTS OF THE PROBLEM.

Although this paper is concerned principally with an attempt to understand the nature of partial or abductor paralysis of the recurrent laryngeal nerve, there are certain clinical misconceptions about laryngeal innervation that one cannot help discussing. There has been a tendency lately to disregard established principles of innervation and to theorize with isolated anatomic or physiologic facts in the effort to explain laryngoscopic findings. For example, the median position of the vocal cord in complete bilateral recurrent paralysis has been attributed in part to the action of the interarytenoid muscle.⁴ This muscle is considered to be innervated by the superior laryngeal nerve, an assumption which can be disproved by several methods of investigation.³⁷

Again, the terminology of the position of the vocal cords has been complicated beyond practical usage. Some of the positions described are median, para-median, cadaveric, resting, abduction, and inspiratory. Even such eminent authorities as Hajek and Grossmann have disagreed as to the position of the vocal cords in a case presented before the Laryngologic Society in Vienna.⁸ The traditional cadaveric position is an indefinite term. According to Semon,³⁸ it is one-third narrower than the normal resting position of the cords. Many workers might call this a median or para-median position. In my opinion, about all that can be determined with accuracy by laryngoscopic examination is whether the vocal cords have lost their ability to abduct (partial recurrent paralysis)

or whether in addition they are partially adducted (complete recurrent paralysis). The term "partially adducted" would include any position from the cadaveric to the median, either of which, according to Terracol³ and Smith and Lambert,⁵ may be found in complete recurrent paralysis.

Isolated paralysis of abduction does not give a median position but merely loss of abduction with perhaps a slightly narrower glottis than usual. Section of the abductor nerves alone in dogs gives little, if any, change in the glottic picture aside from loss of abduction. The partially adducted position of complete recurrent paralysis is due to contraction of the cricothyroid muscle which is innervated by the superior laryngeal nerve. In one-sided paralysis the interarytenoid muscle also assists in adduction, as it is innervated by both recurrent nerves. The degree of tension of the cricothyroid accounts almost entirely for the amount of adduction, and in turn the amount of dyspnea and ability to vocalize present in complete recurrent nerve paralysis. Weleminsky³⁰ concurs in these views and presents a case in which both recurrent nerves were sectioned during operation and yet the patient retained the ability to speak. The cords were in constant adduction due to the unopposed contraction of the cricothyroid muscles which stretched them anteroposteriorly and brought them in to the midline.

In some individuals the tension of the cricothyroid relaxes after a time, due to the fact that it no longer has to work against the pull of the thyro-arytenoid muscle. The laryngoscopic evidence of decreasing tension in the cricothyroid muscle is a shift of the cord from a median to a cadaveric position. This process of relaxation may be so complete as to cause a secondary atrophy of disuse in the cricothyroid muscle, as has been demonstrated experimentally by Grossmann¹⁰ and clinically by Semon.¹ In many cases of complete recurrent nerve paralysis, however, the cricothyroids retain their tone indefinitely. This probably depends on whether vocalization is persisted in or not. In those cases where the cricothyroid remains very tense there is often associated a severe degree of dyspnea which may necessitate a tracheotomy. Before this procedure is resorted to, however, I would suggest that an effort be made to relax the cricothyroid by paralyzing the

external rami of the superior laryngeal nerves with novocain or alcohol. This is theoretically sound and has been used with success for the relief of dyspnea caused by bilateral recurrent nerve paralysis.² The ability to speak is usually lost at the same time that the dyspnea is relieved. Most patients, however, are quite willing to make this sacrifice.

SUMMARY.

The object of this study has been to gain an understanding of Semon's law and some of the clinical implications involved. The various theories about Semon's law are briefly described but not discussed. The problem of isolated abductor paralysis is outlined and the differences between abduction and adduction studied in relation to the central nervous system centers, the laryngeal nerves and the laryngeal muscles. The general biologic aspects of the problem are examined, especially in relation to ontogeny and phylogeny. In conclusion, the clinical side of the problem is discussed, and a relatively simple treatment suggested for the relief of the dyspnea accompanying complete recurrent nerve paralysis.

CONCLUSIONS.

1. Semon's law is a definite law, stating that the function of abduction of the glottis has a proclivity to disease over the function of adduction.
2. The explanation of this phenomenon is that there is a biological, anatomical, and physiological difference between the brain centers, nerves and muscles subserving abduction and adduction.
3. The adductor centers, nerves and muscles are biologically stronger and more resistant to trauma than the abductor centers, nerves and muscles.
4. The abductor nerve fibers are larger, have a lower threshold of stimulation, and are less resistant than the abductor nerve fibers of the recurrent laryngeal nerve. This is in keeping with accepted neurologic principles.
5. The abductor muscles of the glottis contain more lipid granules than the adductor muscles and are more susceptible to trauma and ether.

6. Ontogenetic and phylogenetic studies agree with the above conclusions in that the abductor function develops later and is secondary to the function of adduction.

7. Abduction predominates over adduction in human beings and dogs at birth. In adults, however, adduction becomes the strongest, probably in relation to the development and specialization of vocalization as the predominant function of the glottis.

8. There are many misconceptions in regard to laryngeal paralysis. The tendency to discard well-established principles of laryngeal innervation, such as Semon's law, in the attempt to explain certain clinical findings, is unscientific.

9. Beginning paralysis of the recurrent nerve causes isolated paralysis of abduction with little other change in the glottic picture.

10. Complete paralysis of the recurrent nerves produces a "partially adducted" position of the vocal cords in addition to loss of abduction. The cords may be in any position from the cadaveric to the median, depending on the degree of tension of the non-paralyzed cricothyroid muscles which stretch the cords antero-posteriorly and adduct them. The interarytenoid muscle also contributes to the adduction of the paralyzed cord in one-sided recurrent nerve paralysis.

11. Blocking the external ramus of the superior laryngeal nerve with novocain or alcohol relaxes the cricothyroid muscle and partially relieves the dyspnea accompanying complete recurrent nerve paralysis.

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XI.

CONSTITUTIONAL DEAFNESS.

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Constitutional deafness is manifested by a progressive bilateral loss of hearing beginning at any age and due to some general disease. It is characterized by being accelerated at puberty, during pregnancy and when the patient has suffered from an acute infectious disease. The depreciation in hearing is usually associated with a reduction of the sensitiveness of the static labyrinth but to a lesser extent than the hearing loss. At times the labyrinth may be involved more than the cochlea, and then the condition assumes characteristics of Meniere's syndrome. Constitutional deafness is due to nutritional and toxic disorders. The statement that, in cases in which anatomic defects or concrete pathologic changes can be eliminated, the level of aural acuity as measured by audiometric devices is an index of the nutritional level of the individual¹ gives the above importance. The great majority of patients suffering with this condition have a lowered metabolic rate.

ETIOLOGY.

1. Predisposing causes.

A. Heredity.—The literature is replete with genealogies of families in which deafness is a prominent feature. On the other hand, isolated cases of deafness are constantly being reported and encountered. There is no doubt that heredity plays an important part in the transmission of the factors which make for deaf people. How does this transmission occur? Is the inheritance biological or structural? Does the disease in the labyrinthine capsule and the hearing organ occur without an external activating factor and continue without comparable disease elsewhere? Is the advent of deafness dependent upon a vulnerable cochlea which is inherited?

In a study of the genetic factor in otosclerosis² it was deduced that this condition was hereditary and depended upon two dominant factors: one lies in a sex chromosome and the other in one of the autosomes. It is concluded, however, that for deafness to occur some environmental influence must exist to initiate the condition. In other words, the susceptibility to deafness is inherited. This work is based upon a study of genealogies of families in which deafness occurred. The histories and physical signs in many of the cases studied were incomplete and autopsy material was not common. How the diagnosis of otosclerosis was established in the majority of cases is a mystery. It appears to me that the authors were dealing with cases of chronic progressive deafness of various types due to a variety of exciting causes. The frequency of early dental caries, headache and harmful effects of pregnancy are common and prominent features in the genealogies studied. It will be shown later that dental caries in the deafened is due to nutritional disorders, and the influence of pregnancy is based upon toxic and nutritional factors.

The only cases of deafness which are dependent on heredity without the aid of external activating causes are found in families suffering with *fragilitas osseum*. Here there is a defect in the osteogenetic factors conspicuous by the paucity or absence of osteoblasts while active osteoclasts are present in considerable numbers. This condition is found in long bones as well as in the petrosa.³ The lesion produced is similar to that in otosclerosis except that osteoblasts are missing.

It is possible for the transmission of this susceptibility to be dependent upon the fact that we inherit the structural characteristics of the cochlea of our ancestors. It has been shown that the circulation of the cochlea varies with individuals. In some, the terminal vessels have very little anastomosis,⁴ while in others it is abundant. The cochlea with poor circulation is more susceptible to nutritional and toxic disturbances than the one with rich blood supply.

Recently "The Regressive Theory of Otosclerosis"⁵ was presented to the otologic world. This theoretical structure is erected upon a very insecure foundation. It is based upon the finding of

bony lesions similar to those found in otosclerosis in the otic capsule of a fetus of 7 months. A parallel is drawn between the finding of a closure of a preformed oval window in the herring and other fishes and the ankylosis of the stapes and the obliteration of the round window in cases of otosclerosis. In the cases of the herring and the sturgeon the obliteration of the preformed window is accomplished with normal bone and cartilage. The otosclerotic lesion is distinctly pathologic. It is contended that in otosclerosis there is a reversion on the part of the human labyrinthine capsule to the fish stage. In the case of the fish, I do not consider it to be a regression but rather progression based upon adaptation to environment through natural selection of that which is most salutary for the preservation of species. The sharp variations of temperature of various currents would cause severe labyrinthine disturbances in fish with exposed oval windows unprotected by bony or cartilaginous covering. The species adapted itself to its environment by closing the oval window. There are many evidences in nature of a similar character which may be used to show the same leaning toward natural selection. The calf is born with many rudimentary teeth in its upper jaw which never come to maturity. The change in the shape of the palate, tongue and lips are such that profuse dentition is no longer necessary for the calf to obtain its food while browsing in the meadow. For its progenitors, many teeth in the upper jaws were necessary. Many varieties of beetles have rudimentary wings under their soldered wing covers. By a series of adaptations beetles have adjusted themselves to their environment.

There has always been a doubt as to the ability of fishes to hear. Recently⁶ it has been shown that water-borne sound vibrations activate the galvanometer connected by a lead to the auditory nerve of the pike. From this it is possible to presume that fish do hear even though the range of hearing may be limited. Ossicles and vestibular windows are unnecessary for fish to hear because of the nature of the medium in which they exist. Most likely the sound vibrations reach the rudimentary hearing organ of the fish through the bones of the spinal column. Animals that live in the air require a different transmission apparatus for sound than those that live in the water. Although it has not been proven

experimentally, it is believed that the fixation of the stapes and obliteration of the round window that occurs in otosclerosis produces deafness. Whether profound deafness is possible without involvement of the membranous portion of the cochlea is of utmost importance. I believe that the bony lesion alone in otosclerosis is incapable of producing incapacitating deafness.

It is very likely that the lesion in the hearing organ occurs first and that the bony lesion of the labyrinthine capsule develops subsequently.⁷ This conclusion is based on a study of postmortem findings in early and more advanced cases of the disease. It is presumed therefore that the bony lesions occur independently of the degenerative process in the nerve, although due to the same cause which may be a disturbance of the neurovascular mechanism. In this connection it is noteworthy that I have never encountered prolonged bone conduction in a case of early deafness in which the maximum losses for any of the frequencies was not greater than thirty sensation units. Prolonged bone conduction is commonly found when the hearing loss extends below this figure.

The cases of deafness in which there is a hereditary history may be augmented by the fact that some of the exciting causes of deafness are also hereditary. The number of cases in which there is a family history of deafness ranges between wide limits, depending upon the observer. It is stated that 40 per cent of the cases give such a history,⁸ and a like tendency toward transmissibility is demonstrable in disturbances of the endocrine glands. Endocrine disturbances cause deafness in susceptible individuals. Engelbach⁹ says that endocrine inheritance may be transmitted to the offspring by positive endocrinism or as an inherent, potential or latent state. In 2098 cases of endocrinopathies studied by him there was a family history of endocrine disease in 1,910 cases. A family history of familial endocrinism directly related to the disorder of the patient was elicited in 410 cases (21 per cent).

B. Environment.—The geographic peculiarities of the locality or the geologic formation or conditions in the home do not produce deafness, but these lay the groundwork for diseases which are known to have deafness as one of their sequelæ.

Fetid ozena and atrophic rhinitis is endemic in certain sections of Eastern and Southern Europe. This condition is supposed to be due to an obliterating endarteritis causing an atrophy of the soft parts and bones in the interior of the nose. Deafness is occasionally associated with it. It is presumed⁷ that a comparable condition produces the ear lesion. Endemic cretinism occurs in mountainous regions. It is prevalent in the central Alps, Carpathians, the German middle mountains and the Pyrenees.¹⁰ It is due to the peculiar geologic formation of the terrain in which the drinking water is deficient in iodine. In Ceisleithania there are 71 cretins to 100,000 people, and in Murrau there are 1,000 cretins to 100,000 people. Among these there are many deafmutes. It has been estimated that 29 per cent of cretins are deafmutes and 32 per cent are hard of hearing.

Chronic hepatitis is a common cause of deafness. Rollston and McNee¹¹ state that hypertrophic cirrhosis may attack several people in the same family. It is possible that the liver may be congenitally weak and specific fevers and indiscretions in diet may be sufficient to cause cirrhosis in such cases. They report two cases of portal cirrhosis in one family. These patients were in the habit of eating food soaked in vinegar.

It is likely that environment in the home may be sufficient to produce hepatic disease in several members of a family, and those who have susceptible hearing organs may become deaf. The matter of food, clothing, mental disquiet and bacterial flora common to a family group may operate to perpetuate this condition through generations. I have encountered two sisters with deafness and chronic hepatitis and a mother and daughter with the same condition.

Exciting Causes.²—In considering the exciting causes of deafness, due cognizance has been given to those fixed, immutable forms which result from injurious agents which have ceased to exist in the host but have left partial or complete destruction of hearing in its wake. I refer to the deafness occurring during an attack of meningitis and from the toxemia incident to mumps, scarlet fever, measles, pneumonia and typhoid fever. The loss of hearing in such cases is no longer progressive and does not

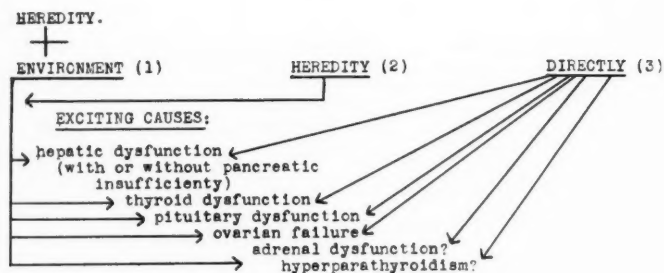


Fig. 1. Constitutional deafness. Schematic representation of Causation. (1) If two or more members of the same family are deaf, they are all likely to have as the exciting cause a common ailment. (2) If two or more members of the same family are deaf, they may have as the exciting cause a variety of ailments. (3) One member of a family may be deaf, this being due to a severe exciting cause.

come within this category. The hearing loss which occurs in tuberculosis and syphilis may be due to local disease in the temporal bone or the result of toxemia, or due to damage to other organs which, in turn, derange the body economy. Excluding the local lesions (tubercular otitis and guma of the hearing organ), both of these diseases may produce depreciation of hearing so long as the disease is active and progressive. These two morbid states, however, are rarely found to exist in cases of progressive deafness. Of sixty-six cases of deafness only one had a positive Wassermann, and another had active pulmonary tuberculosis. Chronic nephritis is another disease which rarely undergoes recovery. Toxemia from this disease may cause hearing difficulty. Out of a large series of cases (over 200), only one was found to have nephritis as the single abnormality which possibly could have been the exciting cause of the deafness.

Logically speaking, deafness which gradually becomes more profound must have as its etiologic factor a condition which is constantly present, irreversible, with slight variations for the better, and with a decided tendency to become more severe as time passes. These conditions are found in liver dysfunction and endocrine disturbances. I have called these exciting causes *morbi sine termino*. In fact, they occur so often in cases of deafness, and fulfill all the requirements for the production of constant and

increasing deleterious agents and conditions, that there seems to be no doubt about their culpability. Out of sixty-six cases of deafness thoroughly examined, fifty-seven had hepatic or hepatic and pancreatic disturbances. Seven were cases of endocrine disease, one had a diverticulum of the sigmoid, and in one case no diagnosis was made. Twenty-three of the fifty-seven cases of hepatic dysfunction had pancreatic insufficiency. Sixteen of the cases that had hepatic dysfunction were complicated by an endocrine insufficiency. The high incidence of hepatic dysfunction in my cases is explained by the fact that I have attracted a large number of cases of deafness suffering with indigestion. Drury¹² believes that 60 per cent of the cases of deafness have an endocrine fault. He says that where the toxic factor is paramount the deafness is most likely due to hepatic disease.

On looking over some of the subjective and objective findings in cases of deafness due to constitutional abnormalities, we find that fatigue, the deleterious effects of pregnancy, headaches, dental caries, contracted visual fields and constipation are encountered in endocrinopathies and in cases of chronic hepatitis.

A complaint of fatigue is found in cases of ovarian and adrenal failure. It is almost always present in cases of hepatic disease and varies from mild to severe lassitude.

The effect of pregnancy in initiating or augmenting the hearing defect in cases of constitutional deafness has not as yet been explained satisfactorily. Pregnancy places a special strain on the glands of internal secretion. The level of ovarian function is lowered during the gestational period.¹³ Given a case of deafness due to ovarian failure, the added influence of pregnancy augments the gonadal disturbance and affects the deafness adversely. One cannot overlook the fact that some women develop an enlargement of the thyroid during pregnancy. The thyroid hypertrophy disappears after parturition. This phenomenon indicates that the gestational state makes additional demands on the thyroid. When the individual is deaf due to thyroid dysfunction, the additional strain on that organ during pregnancy augments the dysfunction and a greater depreciation of hearing ensues. In cases of deafness

due to liver disease the harmful effect of pregnancy is more pronounced. It has been felt for a long time that the toxemias of pregnancy are due in a large measure to liver derangement. Recently, by objective methods,¹⁴ it has been shown that the hepatic factor is a common finding in such conditions. During pregnancy there is a physiologic overload on all the organs and functions. Given a case of gestation in whom chronic hepatitis exists, the additional strain on the liver depresses its ability to cope with the new conditions and toxemia supervenes. If the patient has a tendency to deafness or if deafness already exists, the additional liver derangement either starts or augments the hearing loss. It is well to bear in mind that the liver is the most important detoxicating organ that we possess, and poisons and certain drugs depress the hearing in the presence of a chronic hepatitis.

Headache is a complaint in pituitary and ovarian dysfunction and certainly common in cases of hepatic disease. The headache due to endocrine disturbance is not as persistent and severe as that which originates from liver derangement. In the latter instance the headache is migrainous, at least in its early stages. The association of deafness, migraine and indigestion is a frequent combination. As the condition progresses, the attacks of migraine are replaced by more or less constant generalized headache. Even in the later stages, an attack of migraine may be precipitated by gross indiscretions in diet.

Constipation is encountered in thyroid failure and ovarian dysfunction. In the case of hepatic disease, constipation is always present. At times it alternates with attacks of diarrhea. In histories of cases of constitutional deafness constipation is frequently recorded.

Contracted form and color fields are frequently encountered¹⁵ in cases of constitutional deafness. It is found in endocrine dysfunction and chronic hepatitis with or without deafness. It is an expression of toxic and nutritional disturbances of the nerve mechanism of sight, expressing to a less extent the influences of these diseases on the auditory organ. In pituitary dysfunction the contraction of the fields is more common than in thyroid and ovarian cases. Enlargement of the blind spot is more likely to

occur with pituitary dysfunction than with the other endocrine disturbances. It is not necessarily associated with increase of the size of the hypophysis.¹⁶ As is well known, liver dysfunction is often associated with failure of one or another endocrine gland. The combination of thyroid and hepatic dysfunction is commonly encountered. When this association exists the contraction of the form and color fields is likely to be an expression of the several etiologies.

One is amazed at the number of cases of deafness that have extensive caries of teeth, or who has lost many teeth at an early age. On the other hand, there are many cases of constitutional deafness who have no such difficulty. Dental caries is likely nutritional in origin. Deficiency in phosphorus and calcium may have a profound influence in its production. There is no doubt that the glands of internal secretion control the metabolism of elements which enter into the formation of bones and teeth. The influence of the parathyroid when overactive in the production of osteitis fibrosa cystica is common knowledge. The pituitary gland plays a prominent part in the growth and development of the bony framework. When it is diseased, abnormalities of the skeleton at times supervene. Dwarfism and gigantism result from malfunction of the pituitary occurring during the early life of the individual. Pituitary tumors produce acromegaly when full development is already established. It is generally conceded that calcium metabolism¹⁷ is influenced by the level of ovarian function. Occasionally after castration thickening of the ends of some of the bones producing arthritic symptoms is encountered. Loss of teeth due to caries is a common occurrence in ovarian failure. The inadequate and improper absorption of calcium, phosphorus and sulphur, etc., due to disturbances of the digestive apparatus, is instrumental in producing nonresistant teeth, osteoporosis and other diseases that are related to nutrition. Among these may be mentioned osteomalacia, and probably Paget's disease. The liver dysfunction and pancreatic insufficiency so frequently encountered in cases of constitutional deafness are factors capable of producing such nutritional abnormalities. The lesions of the petrous portion of the temporal bone found in osteitis fibrosa cystica, Paget's disease and osteomalacia are indistinguishable from the

isolated lesion of otosclerosis. Deafness is occasionally encountered in cases of osteitis fibrosa cystica, Paget's disease and osteomalacia.

Diagnosis.—The local lesions which are capable of producing deafness must be first excluded. These include cerebellopontine angle tumors, syphilitic lesions, tuberculosis and chronic suppuration. The latter is not always the cause of profound deafness. As a matter of fact, the hearing loss produced by chronic suppuration or the residual fibrosis is not severe unless the disease invades the labyrinth. A constitutional ailment occurring in a case that has or has had disease of the middle ear usually produces most of the deafness.

The diagnosis of the general disease is a medical problem. It is here that the internist can assist the otologist in solving the perplexing problems which confront him. The frank case of endocrine disease or liver dysfunction requires very little diagnostic acumen or laboratory aid. It is the case that is not fully established that taxes our resources and often needs elaborate vital function studies to illuminate the picture. Even here, experience and rare judgment coupled with a consuming interest are vital to the proper solution of the problem. It must be remembered that mild types of dysfunction are sufficient to produce deafness in a susceptible person. It is these that must be uncovered and corrected. Then satisfactory results will be obtained.

The cases of chronic hepatitis which are encountered with deafness are those that have no jaundice, although many have an icteric tinge to the sclerae. In the early cases the liver is not palpable, but later the lower border may be felt below the ribs as a sharp resistant edge. Many of the cases have few symptoms and these are not very disturbing. Belching and constipation may be the only complaints, and yet the patient is progressively losing the hearing due to a low grade hepatitis. Some have chronic appendicitis which is a common cause of liver disturbance.

The laboratory findings in cases of uncomplicated chronic hepatitis are a lymphoid blood, indican in the urine, icteric index above the high normal figure, blood sugar at or below the low

normal limit, galactose tolerance diminished by 25 to 33 per cent, systolic blood pressure at or below 110 in the majority of cases, and the metabolic rate is lowered anywhere from -10 to -17 . The diagnosis is definitely established by quantitating the bile pigments, cholesterol and bile salts in the duodenal contents. In addition, the enzymic concentrations of trypsin, amyllopsin and lipase may be estimated to determine the efficiency of the external secretory function of the pancreas. The methods of McClure and his associates^{18 19} are used for this examination.

In the endocrine cases greater losses of hearing are observed in the speech area than in the high or low notes. This gives the audiometric curve a broad U appearance. The hearing curves of cases of hepatic dysfunction with deafness display maximum losses in the high tones, the greatest drop occurring at the 4096 D. V. frequency. In cases of deafness in which both hepatic and endocrine disturbances exist, the curve is modified to assume a shape more in conformance with the major abnormality.

Prognosis and Treatment.—Improvement in hearing is not to be expected in cases where the deafness is profound and has existed for a long time. In such cases the degenerative process in the cochlea has produced death of parts of the hearing organ which are replaced by scar tissue. However, there are cases of constitutional deafness that look hopeless because of the severity of the affliction and yet with suitable treatment the hearing improves. In the early cases restoration to normal after a reasonably short time may be expected. I believe that our greatest function lies in the field of prevention. The hearing of children should be examined yearly, and when a drop occurs vital function studies should be undertaken and such abnormalities found should be corrected.

The treatment should be directed to a correction of the exciting cause of the deafness. Continuous medication is indispensable. A willingness to review the case when improvement does not occur and change one's opinion in the light of new information is essential. Success cannot be obtained without a sympathetic co-operation between patient and doctor.

2 WEST EIGHTY-SEVENTH ST.

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XLI.

HEAD AND NECK MANIFESTATIONS IN METABOLIC DISORDERS.

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In August, 1932, Mrs. J., age 54, was referred to me with complaint of irritation and scratching in the throat of several months' duration, which was not relieved while under the care of her family physician. Examination of her throat disclosed the presence of two oval, pea-sized, yellowish-brown nodules behind the right posterior pillar. Their surfaces were smooth and they were freely movable. There were no other positive findings of the head and neck excepting the presence of very small yellowish plaques in the skin of the eyelids. The patient's throat did not respond to local application, and she was accordingly advised to have an examination by an internist, to be followed by surgical excision of the nodules. A fairly well advanced diabetes was found and proper treatment was instituted. A few months later the patient returned for observation, stating that her throat symptoms had disappeared some weeks after beginning the antidiabetic regime and that she was anxious to avoid any surgery. On re-examination the nodules were still present but of definitely smaller size. Surgery was postponed for the time being and patient was advised to return for further observation if symptoms recurred.

From the foregoing history and study of the literature, I felt that a diagnosis of xanthoma was the probable one. In making a further investigation of the literature I was surprised to find a number of articles, practically all in foreign journals, which dealt not only with conditions similar to what I have described, but also many other types of depositions and symptoms of the head and neck, associated with some disturbance of metabolism. From a study of these works and standard texts on pathology, I shall endeavor to present to you a concise and instructive account of these various manifestations. It appears that only in the last decade have changes in the upper air passages caused by abnormal metabolic processes been subjected to investigation, and this study has been greatly aided by the newer developments in chemical, blood and tissue analyses. In the consideration of head and neck symptoms based on abnormal metabolism I shall first describe the various deposits, the most common of which is xanthoma, also called xanthelasma.

This disease makes its favorite appearance around the eyelids (xanthoma palpebrarum) in the form of very small buff or yellow colored plaques. These are smooth, round or elongated, varying in size from a pinhead to a pea, although some as large as a walnut have been reported. The generalized form of xanthoma (xanthoma multiplex) is less common and may appear in the form of xanthoma planum or xanthoma tuberosum. The lesions in xanthoma multiplex usually attack both skin and mucosa, the latter sites most commonly being the buccal and laryngeal mucosae. Rhodes, in 1906, and Logan Turner, in 1925, reported two cases of extensive xanthoma multiplex of tuberosus type which so involved the larynx that tracheotomy was necessary. As to etiology, xanthoma in the young is usually congenital, whereas in older people it is most commonly associated with conditions in which the cholesterol content of the body tissues is increased, viz., diabetes, jaundice, nephritis and gout. Some cases have no apparent constitutional cause and accordingly are named essential xanthelasma. Xanthoma is more common in women and, as stated above, usually makes its first appearance about the eyelids, the progress of the disease being rather tardy. Xanthoma of diabetic origin manifests a tendency to spare the eyelids and locate itself in the mouth. The lesions here progress rapidly but may spontaneously disappear. The diagnosis can be clinically established, especially when there are associated dermal lesions. Definite verification may be obtained by histologic and histochemical means. Histologically, all the cells of an affected tissue are involved in this process of lipid deposition. In paraffin or celloidin preparations these lipoids are extracted by the alcohol and give rise to the typical foam cell. These lipid deposits also have their particular physical, chemical and staining characteristics. In consideration of the therapy, appropriate treatment of the associated metabolic disease will at times cause these lesions to recede. Fat and cholesterol-poor diets, arsenicals, potassium iodid and radium are recommended, and surgical removal may be necessary if the lesions hinder the function of the pharynx or larynx.

In addition to xanthoma palpebrarum and xanthoma multiplex, under the general heading of xanthomatosis, another symptom-complex is included, i. e., the Schüller-Christian syndrome. These

various forms of xanthomatosis are fundamentally the same process, but with different expressions, all being the end-results of a process in which the body is unable to handle lipoids normally. Rowland believes that these processes start with excess of lipoids in the body tissues, but contrary to other authors, he claims that these lipoids are stored only in the reticulo-endothelial cells. The Schüller-Christian syndrome was first described by Schüller in 1916, and Christian reported the first case in this country in 1919. This syndrome consists essentially of defects in membrane bones, diabetes insipidus and exophthalmos, but it is important to stress that they need not all be present to establish a diagnosis. "The diabetes insipidus is present only if there is a deposit of the cholesterol around the region of the pituitary body or destruction of the bony support of the gland, and the exophthalmos is dependent upon the destruction of the roof of the orbit by the process. One of the most common symptoms and one of the earliest signs is involvement of the teeth and gums in children by an ulcerative inflammatory process, classed as gingivitis, which results in loosening of the teeth and sometimes the loss of the tooth or teeth involved. This is found to be due to a deposit of the lipoids at the apex of the tooth. Likewise jaundice is one of the common symptoms, due to involvement of the Kupfer cells of the liver. Cessation or retardation of growth is nearly always present and malnutrition is often a striking general symptom. The only finding common to all is the defects in the bones of the skull, although either diabetes insipidus or exophthalmos or both were present in the large majority. The most important point in the diagnosis, roentgenologically, is the presence of defects in the skull or pelvis or both. They involve the inner table of the skull more than the outer, and have distinct, clear-cut but irregular edges and often present a map-like or geographical appearance. The involved areas may present soft tumor-like swellings, but more frequently there is a depression or defect palpable as well as visible. Spontaneous remissions occur, and in addition an active remission may be produced by low fat and cholesterol diet, insulin and high caloric diet. Most beneficial results have been obtained by X-ray therapy over the lesions. It permits general improvement and has proved to be efficacious for the secondary results of the disease.

such as diabetes insipidus and exophthalmos" (Sosman). Pituitrin controls the diabetes insipidus in all cases. Prognostically, about one-half of the cases reported have died and the others are living, so far as is known. According to Sosman, it is probable that due to the rarity of this disease in adults and the spontaneous remission in the cases surviving the childhood stage, it would suggest that either a tolerance is acquired or that the provocative lesion heals or disappears. Therefore, if one can tide over the severe, early stages, we may expect either a remission or a decrease in the severity of the disease with a coincidental improvement in the outlook. As a palliative, locally very effective measure, roentgen treatments seem to be of prime importance.

At this time I would like to say just a few words about extracellular cholesterinosis, which was first described in 1930 by Kerl of Vienna. This condition is either quite rare or unrecognized and is one in which cholesterin and cholesterin esters are deposited outside the tissue cells and is usually associated with hepatic disturbances in which increased cholesterin is present in the tissues. The lesions appear on the skin and the mucosa of the upper air passages as yellowish-blue nodules of glassy transparency and peculiarly associated with local varicosities. The diagnosis is established histologically and histochemically. Therapeutically, X-ray radiation seems to have given fairly good results up to the present.

In 1924, Urbach and Wiethe first investigated and described a form of lipoidosis, characterized by the extracellular deposition of an acetone-soluble lipoid in physical combination with an unknown albumen. They named it lipoid proteinosis, and such cases have since been reported by Kindler, Benesi, Rössle and others. Wiethe and Urbach consider the cases reported by Siebenman and others in the past as unrecognized cases of lipoid proteinosis, labeled as sclerosis of mouth, pharynx and esophagus. According to Wiethe, this disease usually begins in the first few weeks of life with the symptom of hoarseness. The course is chronic and the lesions first appear in the laryngeal mucosa and later in the skin. These cases, when first seen in adult life, usually give a history of repeated mouth and throat inflammation and present at the sites of the early skin lesions variola-like scars. The most prominent manifestations, however, are found in the mucosal lesions which

are all quite similar in appearance. They present themselves as yellowish plaque-like elevations on the inner surface of lips, palate and inferior surface of the tongue; the areas of predilection, however, are the lymphoid tissues of the throat. The tongue is usually infiltrated and less mobile, the taste buds being moderately degenerated with resultant poor taste. The involvement of the larynx may be so marked as to necessitate tracheotomy. The mucosæ of the esophagus, vagina and urethra are at times similarly affected, and as in the lesions of the mucosa that I have mentioned, no ulcerations as yet have been observed. The clinical appearance of the lesions on the skin and mucosæ are so characteristic that a diagnosis can be made without any further investigations. Histologically the disease is characterized by a deposit of homogenous masses, with thickening of the vessel walls; histochemically, the nature of the lipoid can be definitely determined. As to the etiology, a large number of them are associated with diabetes. However, any attempt at cure with insulin or fat-poor diets is usually of no definite value. Treatment with radium and other measures have not given, up to the present, any favorable results.

It is interesting to note, in this regard, that in 1930 Lebedeva of Leningrad reported the results of his microscopic investigation of lipoid deposits in the larynx and trachea of forty-two cases and arrives at the following conclusions: The deposit of lipoid substances in the walls of the larynx and trachea occur in the form of diffuse infiltration of the fibro-elastic tissue, in the glands of the mucosa, in the cartilage cells and the wandering cells of the connective tissue. The involvement of the fibro-elastic tissues begins at the age of from 25 to 30 years, and is observed in all cases past 40. No deposit was found in the fibro-elastic tissue of the vocal cords. In practically all cases over 30 years, he found deposits in the cartilage cells with exception of the epiglottis.

The next form of deposition I wish to mention is amyloid. This is an albumenoid body which is at times deposited as a tumor or infiltration in the upper air passages. Pathologically, amyloid degeneration is a process by which the basement substance of various forms of connective tissue, and especially walls of blood vessels, become swollen and thickened by their conversion into

a translucent, firm, glassy material, albuminous in character and definitely differentiated by its appearance and staining reactions. According to Eugen Pollack, amyloidosis is either local or general. The general form most frequently occurs in association with severe wasting diseases such as chronic bone suppuration, tuberculosis, syphilis and malaria. Local amyloidosis, on the other hand, is most common in the conjunctiva, air and food passages, and has no relation to the general form I have mentioned, but is probably associated with some local disease. The majority of reported cases of amyloid tumors in the field of otolaryngology have been those with tongue and laryngeal involvement. Why amyloid tumors always occur in the same portion of the tongue, viz., posterior to the circumvallate papillae, is not clear, although various explanations have been suggested, such as the comparative frequency with which the follicular glands are subject to inflammatory processes, developmental confusion of that part of the tongue because of the thyroglossal duct, etc. Whether occurring in larynx or tongue, the tumor is circumscribed and firm, usually pea-sized, although larger ones have been reported. The color of the tumor varies from yellow to red and possesses a peculiar transparency. The usual form of therapy has been surgical removal and at times after only partial removal the remnants disappear.

Another uncommon form of deposit which we may encounter is calcium. Either the cells or intracellular substance may be involved in the process of calcification, giving hardness, brittleness and a whitish appearance to the affected parts. Calcium is usually deposited in the form of the phosphate and carbonate in dead tissues or those of reduced vitality, this process being termed dystrophic calcification. Hajek reports the finding of calcium deposit in chronically inflamed antral mucosa and also in tonsil capsules of patients with chronic tonsillitis. As an example of calcification of masses of secretion and excretion, we may mention tonsillar calculi in which masses of epithelial cells, bacteria, etc., are infiltrated with calcium salts. Of similar character are the bronchial calculi and calculi in the ducts of the salivary glands.

For the sake of completeness, I make mention of dye and pigment deposits in so far as they concern the field of head and

neck. The most common form which we encounter is of course icterus, brought about by deposition of bile pigment in the body tissues. The most significant localizations are those of the inferior surface of the tongue, epiglottis, vocal cords and tracheal mucosa. A form of yellowish discoloration, often mistaken for icterus is xanthosis diabetica, occurring in some diabetic individuals, and depends solely on the ingestion of green vegetables in the diet, having no relation to the severity of the diabetes.

My outline thus far has dealt with the various depositions in the head and neck brought about by metabolic disorders, but these are not the only manifestations. Of much more frequent occurrence in our domain are the sensory disturbances caused by errors of digestion and endocrine function. I shall allude to these briefly since reports of detailed investigation are rather plentiful and are beyond the scope of this presentation. We find many case reports of patients, especially women, who complain of sneezing, nasal blockage and watery discharge, a symptom complex to which the name vasomotor rhinitis has been given and usually associated with this complaint is chronic constipation. The etiology here is rather definite, since a change of diet and relief of constipation has given a good percentage of cures. In this regard we might associate Quincke's edema and urticaria, which are considered as due to intestinal absorption of split products and here, also, the rational therapy is change of diet and catharsis.

In reference to vasomotor rhinitis associated with dysfunction of the thyroid, I mention the investigations of Dr. Frank Novak with which you are acquainted. In fairly advanced stages of hypothyroidism, myxedematous changes in the mucosæ of the nose, pharynx and larynx occur, these symptoms disappearing or improving under thyroid medication. At this time it may be appropriate to recall to you the publication of Pratt in which he suggests that atrophic rhinitis is caused by a dysfunction of the thyroid gland.

The parathyroids which normally control calcium metabolism may, under certain conditions, function below par and allow a decrease of blood calcium with the development of tonic cramps. As a probable example of this, laryngismus stridulus in children may be mentioned. In adults, however, laryngospasm is rare in

parathyroid tetany, the usual spasms being located in the extremities. Cases of idiopathic tetany with laryngospasm have been reported, usually occurring in young adults and at times so severe as to render tracheotomy necessary. This form of laryngospasm is probably of parathyroid origin, since treatment with Collip parathyroid extract has resulted in permanent cure.

Furthermore, alteration of ovarian function presents a group of symptoms in the upper respiratory tract which are well known. Examples of such are the vicarious menstruations and vasomotor rhinitis associated with amenorrhea and dysmenorrhea; laryngeal and nasal edemas occurring during pregnancy; pharyngeal and laryngeal neuroses at the climacteric, etc. The majority of these symptoms clear up when the contributing factor has been eliminated.

In concluding, I wish to state that my object in presenting this subject is to draw attention to some of the less common head and neck symptoms associated with an alteration of metabolism, which by virtue of their remote origin are likely to be overlooked.

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XLII.

PRIMARY BRONCHIOGENIC CARCINOMA: INCIDENCE, PATHOGENESIS AND DIAGNOSIS.*

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During the last half century primary lung cancer has sprung from obscurity into a rather common disease. It is so common that everyone interested in chest, throat, nervous diseases and many other specialties should always have it in mind in diagnostic work.

It is unnecessary here to give any historical background of the subject, but we shall rather point out the increase in incidence. Reinhardt¹ in 1878 collected 25 cases; by 1896, Päässler² collected 54; by 1912, Adler³ had collected 374, with two other doubtful groups of about 100 each; by 1918, McMahon and Carmen⁴ could find 428 authentic cases, and since then reports have been coming in by the hundreds, until recently Dr. Hruby and I⁵ gathered 2,359 cases that were reported in yearly or five-yearly periods and on which there were complete collateral observations. It is our opinion that this represented roughly half the total reports. Within fifty years the increase is about tenfold. This apparent increase would not be so significant were it not established on reliable autopsy findings. Nevertheless, we must use care in the interpretation of autopsy figures. Their absolute nature is less convincing when we consider that in Germany, for example, according to Lubarsch,⁶ only 5 per cent of all bodies are autopsied, and in America Karsner⁷ estimates that only 0.7 per cent come to autopsy. It should at least prompt caution in drawing conclusions until more is known of the 95 per cent and 99.3 per cent, respectively.

By careful analysis of the problem, therefore, it is evident that part or perhaps much of this increase may be accountable on (1)

*Presented before the Chicago Laryngological and Otological Society, December 4, 1933.

Municipal Tuberculosis Sanitarium Laboratories, Chicago.

an increased life expectancy, throwing nearly 100 per cent more into the cancer age than existed fifty years ago; (2) increased knowledge in the cause of certain diseases (tuberculosis, bronchiectasis, etc.); (3) the tremendous effect on diagnosis brought about by the X-ray, bronchoscope, etc.; (4) increased zeal on the part of the medical profession and laity (better hospitalization, better transportation, more autopsies on unusual types of patients, etc.); and finally (5) a changed attitude in pathologic interpretation of lung cancers, placing in this group many that were considered metastases or sarcomas.

That the various diagnostic facilities have had their effect is proved by the fact that diagnosis of lung cancer has increased with the use of the new measures, and almost in proportion to the rise in the lung cancer figures. The percentage diagnosis at the beginning of the century was not over 5 per cent correct (that is, 95 per cent were discovered at autopsy). As late as 1925, the percentage diagnosis had barely risen to 47 per cent (Lubarsch), but everyone around a large hospital knows how the diagnosis of an unusual malady will cause everybody to work hard for an autopsy to confirm the unusual diagnosis. This results in an increase in autopsies on such special cases.

At least we should hesitate to proclaim a true increase until more is known of the dead that are not now coming to autopsy.

For the sake of argument, let us see if we are able to discover any accountable reason for a true increase in lung cancer. Statistics reveal that there is practically no increase in cancer in other parts of the body that cannot be accounted for by increased life expectancy. Therefore, we must search for some unusual or specific irritant to account for the abrupt and tremendous alleged increase in lung cancer, since otherwise there ought to be no difference from cancer in general.

Even though there may not be a fundamental biologic reason for an increase, there are certain facts presented by reliable authors that cannot be ignored. For example, there is definite proof that radio active dust causes an increase in lung cancer, as revealed by the studies of Arnstein,⁸ Schmorl,⁹ Sikl and Perchan,¹⁰ on pitchblend miners of Saxony and Bohemia. But this group is small and certainly has no importance as a cause of lung

cancer in general. It merely shows that such an agent will lead to malignancy, but this is to be expected, since overdoses of radium will always lead to such results. It also raises the question, however, whether other irritants may not also do the same thing. Winternitz,¹¹ Askanasy¹² and others have shown that influenza causes a destruction of the bronchial epithelium that has all the characteristics of neoplastic development on regeneration. Nevertheless, Hueper¹³ could find no increase following the epidemic of 1893. For reasons given above, however, they may have overlooked them. Although it will take another decade before we can be sure of any effect of the last influenza epidemic, it seems to be clear now that influenza can at most account for only a small portion of the increase, especially since the great rise of lung cancer was well under way before the epidemic of 1918 occurred. Furthermore, only a small percentage of lung cancers give a history of influenza, and the preponderant number of patients having influenza do not have lung cancer.

Recently McNally¹⁴ has pointed out that the increase in lung cancer parallels the consumption of cigarettes. This theory is one that offers one of the best explanations that has been suggested up to the present time, because of the close conformity of the lung cancer curve to the increase in the consumption of cigarettes. Nevertheless, more apparent things than that have failed to prove up, so we must wait and see what experiment will bring. If there is any merit in this theory, it should be manifest in the female sex, where the increase in the use of cigarettes has been greater than in men. If, for example, the ratio of men to women twenty years ago was 3 to 1, and now it is 1.5 to 1, the case is well nigh proved. So far, no such increase in ratios has appeared, for the sex ratio was and still is around three males to one female, similar to other malignant conditions other than those of sex differences. On the other hand, there are many patients with lung cancer who do not give a history of cigarette smoking at all.

As other suspected factors are studied, the probability of their relationship to the cause of lung cancer becomes more remote, and in fact many approach the realms of improbability. Such, for example, are the various chronic diseases that have been accused—certain races, smoke, dust, tar, dusty occupations, and many

more, none of which when critically analyzed produce more lung cancers than the others, and all have a proportionate quota not having the disease.

After carefully studying the many possible agents accused of causing lung cancer, it seems that only the radium ores can be definitely indicted. But this is an expected result and certainly is in a different category than most other irritants, because radium emanations brutally alter the germ plasm of any germinative cell.

More and more it is appearing to be a deep seated problem with the question of a true increase far from an established fact. The probabilities are rather leaning toward the increase being a relative one brought about by a number of factors with the onset of the disease initiated perhaps by a variety of irritants similar to that of the origin of cancers elsewhere. There seems to be a fundamental and inherent tendency in the particular patient that is provoked to activity by a great many exciting factors. The increase in lung cancer to a considerable extent, therefore, can probably be accounted for on a relative basis, and the reported rise in incidence should not provoke undue alarm. Rather, it should bode well and not ill for the public health. It should be, as Wells¹⁵ said about cancer in general: "A high cancer death rate is an indication of good state of public health."

Along with the numerous developments in diagnosis, the conception of the mechanism of the origin and development of lung cancer was also undergoing a change. Owing to the fact that gross pathology is so irregular, nothing can be gained by reporting any details of classification further than to state that three types have been reported, viz.: a nodular, an infiltrating, and a miliary type. Neither is there any relation between gross and microscopic findings, or gross findings and histogenesis, except that pure squamous cancers tend to remain localized. The histology is also a poor guide to the pathogenesis of these tumors. The fact that the tumors are medullary, scirrous or simplex; alveolar, acinar or adenomatus, offers little towards an understanding of the origin. The outstanding fact is they are epithelial in origin and, therefore, are carcinomatous.

Waldeyer,¹⁶ in 1867, was one of the first to advocate the epithelial origin. Langhans,¹⁷ Chiari,¹⁸ Ebstein¹⁹ and others suggested the origin in mucous gland, while Ehrlich,²⁰ Päessler² and others suggested the origin from the bronchial epithelium. There has been much controversy over these two sites of origin as well as the little understood and doubtful origin from pulmonary alveoli. Throughout all the discussions of origin there has been the reliance on these three groups founded on histopathologic appearances of the cancer after death. In the early works of Perls,²¹ Fuchs²² and others the origin from the pavement cell types were thought to be from the pulmonary alveoli by a retrograde metamorphosis, but this ground is untenable for several reasons, principal of which is that most of these forms can be shown to arise from the main stem bronchi. The alveolar cell type is now restricted to a very small and special group typically represented in the reports of Grünwald²³ and also Kretschmar²⁴.

The origin from bronchial mucosa has always had numerous advocates, and they are increasing if not actually becoming the predominant group. If there is any merit to the theory of origin from bronchial mucosa it will necessitate the proof of some form of metaplasia from one type of tissue to another.

For the purpose of a clearer understanding, let us review the embryology and anatomy of the lungs and bronchi to see what changes take place in normal repair of such injured tissue. The original lung bud contains a hollow, bifurcate tube lined with a double layer of epithelium, a basal cuboidal and a superficial columnar that becomes both ciliated and mucous bearing. This layer extends down to the smaller bronchioles where only a ciliated columnar layer is found. Further on the cilia disappear and finally the cells become cuboidal, and over the alveoli they are flattened out to plates. Miller²⁵ is of the opinion that this condition persists throughout adult life. On the other hand, Rose,²⁶ in Oertel's laboratory, and recently Fried²⁷ cast doubt on the epithelial origin of alveolar cells. The latter shows that these cells are phagocytic in nature and can be seen emerging from the deeper tissues of alveolar walls and must, therefore, be mesodermal in origin. This controversy is still unsettled, as indicated by the neutral position of Maximow.²⁸ Irrespective of the controversial

phase of this subject, an injury to any part of the bronchus will normally heal as any other tissue. Such healing has been observed by McKenzie,²⁹ Kitamura³⁰ and Friedländer³¹ in certain acute and chronic lung diseases; by Askanazy¹² and Winternitz¹¹ in influenza; by Fried and others experimentally; and I have seen abundant examples of re-epithelialization of cavities of chronic Friedländer's pneumonia and tuberculosis.

The question is when and how does malignancy begin? The opinion seems to be best expressed by McCarthy³³, in 1915, and later by Moise,³² Fried²⁷ and others in ascribing the change to a form of indirect metaplasia originally proposed by Ribbert³⁴ or to the "histologic accommodation" theory of Hanseemann,³⁵ called anaplasia. In both of these the changes are more or less slow and limited. In most tissues there are adult cells and regenerative cells, or cells that may act as germinative cells. After a destruction of the adult tissue the regenerative cells (usually from a basal layer of the tissue) grow out to replace the destroyed cells. Most of the time this occurs without ill results, but if a malignant tendency exists in the host, malignant cells may emerge from the basal cells and a cancer results. The particular irritant at the time is generally incidental.

It would not seem necessary, therefore, to assign multiple sources of origin of lung cancers because all can be explained on the basis of origin from the basal layer of the bronchial mucosa. This is more evident when we realize that a large number of these cancers simulate a variety of cellular types, including small round cells, large, round squamous cells, keratinized cells, mucus-bearing cells, cuboidal cells (oat cells), ciliated cells, and other cells of bizarre shapes and sizes. What is more significant, many of them appear in the same specimen or even in the same group of cells. This suggests a widely varied, indirect metaplasia at the time the malignant tendency begins, just as occurs to a less degree in benign re-epithelization, cited above. There seems to be a multipotential nature of the basal cells that is inherent in all, whether in simple regeneration or in malignant development. The only difference is that one type is limited and the other shows various degrees of unlimited growth. Whether they become malignant or not depends upon the inherent character in the particu-

lar individual. Cancers that arise from the pulmonary alveoli are very rare, if they exist at all.

The most common location of the lung cancer is the main stem bronchi near the bifurcation. On this account it will permit the use of bronchoscopy in establishing a diagnosis in well over half the cases, as well as directing treatment in a sizeable percentage. I wish to emphasize, however, that the bronchoscopist should not expect to obtain a piece of tumor every time he tries, for the tumor may be too far down the bronchi or may be in the upper lobe bronchi, out of reach. Any interference with normal rhythm of bronchial action, however, should be a significant observation. The fixed or woody bronchus reported by Jackson²⁰ and others is important.

Like cancers elsewhere, the degree of malignancy varies and there is little correspondence between cell type and degree of malignancy. Types that spread slowly are the purely keratinized, squamous cell type and scirrous forms. The others spread slowly or rapidly, depending on the age of the patient, amount of connective tissue stroma, etc. The slow-spreading types present an X-ray picture of a round circumscribed tumor; while the more rapid-spreading forms present a diffuse picture type with hazy borders. In the latter, tumor cells soon reach the pleura, where it produces the encasement of lung with a tumor-coated pleura. Such forms produce the dense X-ray shadows simulating fluid and are usually the cause of an unusual type of pain. They also penetrate the pulmonary veins in one or several places and produce widespread metastases. This was well shown in some recent work by Dr. Hruby⁵ and myself. The prognosis of such tumors is bad from the start, but the other types may offer some hope of early surgery, either by bronchoscopic treatment or lobectomy. Sometimes cancers arising far down the bronchi penetrate the pleura and produce a tumor simulating a pleural endothelioma. We apparently found one of this type. Other tumors seem to arise far enough down the bronchi, or at any rate the inherent characters are such that development of a uniform type of cuboidal cell results which grows into the alveoli and supplants the normal alveolar cells. There results a special type of "alveolar" lung cancer, that is different in practically every respect from any

others. This was first accurately described by Grünwald²³ and Kretschmar.²⁴ The essential features besides the alveolar appearance is that in gross appearance it resembles a pneumonia in the gray stage of hepatization. The extension usually occurs by the lymphatics or direct implantation from one bronchus to another.

From the various facts stated above, the extension of the tumors may be seen to occur in one of several ways, viz.: by direct extension, by the lymphatics, by the blood stream, or by two or more of these methods.

Now, regarding the diagnostic factors, I shall be very brief, inasmuch as two representative men in Dr. Hruby and Dr. Potter are to follow.

A gradually appearing cough (commonly in men past middle life), followed by a variable but constant pain and expectoration of sputum frequently streaked with blood; all of which may be accompanied or followed by dyspnea. This forms the chief symptom triad. Other less common signs are anorexia, fever, loss of weight, symptoms due to pressure (dysphagia and aphonia) and a variety of symptoms due to metastases. Many of the latter are of the nervous system. The physical signs reveal the presence of a gradually increasing bronchial tumor, with limitation of motion of the affected side, slight or no moisture at first, decreased breath sounds distal to the bronchial obstruction, hyperresonance above, dullness and ultimately flatness over the tumor. The roentgenogram reveals a gradually progressing growth of the tumor out from the hilus or along a bronchus, and the growth may be diffuse or circumscribed. The endoscopic view reveals a "woody" or fixed bronchus, and a study of a bronchoscope section when properly stained generally clinches the diagnosis. This method fails when the tumor is in the smaller bronchi.

The laboratory examination should first reveal a scant or mucoid sputum, sometimes streaked with blood or tinted with hemoglobin, free from tubercle bacilli. Later the tumor cells should be found in the sputum or pleural fluid. We have established a diagnosis in two cases on sputum section, one when the bronchoscope failed. Such early findings offer the only opportunity for permanent therapeutic aid.

First, facts available at the present time do not justify the conclusion that there is a true increase in lung cancer. Rather, we should take hope that for the greater part a better type of medical work is revealing more cancers than in the past and that our chances of survival are better than before.

Second, lung cancers are similar to other cancers in their origin, from a basal and embryonic type of cell. This cell is the basal cell of the bronchial mucosa that through some inherent derangement of the germ plasm fails to reproduce injured tissue according to its normal purpose, but grows out in an anarchistic fashion simulating all types of ancestral epithelial cells. The resulting tumors may be slow growing and circumscribed or infiltrating and metastasizing, depending on the type of the malignant cell to age of the person, the amount of connective tissue, etc.

Third, these tumors produce X-ray shadows and symptoms according to their type and extent of growth. The earliest type usually produces only a local irritation leading to cough, a mucoid sputum sometimes tinged with blood. It is too small at this stage to cast an X-ray shadow, but may be seen by means of the bronchoscope. The circumscribed type usually is painless for a long time but casts a discrete X-ray shadow. It may cause cough and dyspnea due to pressure and physical signs of tumor. The infiltrating types produce hazy, indefinite X-ray shadows, but are the kind that produce bleeding, cough, early pain and distant metastases. The bronchoscopic view will usually show a variety of tumor formation in the bronchus or a fixed and woody bronchus or both.

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XLIII.

THE ELECTROCAUTERY IN TREATMENT OF LARYNGEAL TUBERCULOSIS.*

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EL PASO.

Laryngeal tuberculosis is a serious condition, and as a rule is secondary to pulmonary tuberculosis. The infection is thought to take place most often through the lymphatics or from infected sputum passing over an abraded surface. The frequency of this complication varies according to the gravity of the pulmonary condition and has been given as 20 to 50 per cent, depending on whether one is dealing with incipient or far advanced cases.

In studying the lists of patients cared for during the past several years in El Paso's institutions for tuberculosis, I am surprised at the small percentage who have had laryngeal tuberculosis. At the William Beaumont Army Hospital there have been admitted 2,450 cases of tuberculosis since 1921, and of that number only 80, or $3\frac{1}{4}$ per cent, were diagnosed as having laryngeal tuberculosis. Most of these patients were ex-service men, varying in age from 30 to 50 years, with a rather high degree of immunity.

The private sanatoria of El Paso, Hendricks-Laws, Homan, Long, Price, and St. Joseph give percentages of laryngeal tuberculosis varying from 12 to 20 per cent. In 2,066 cases of tuberculosis treated in Homans, 13.2 per cent had laryngeal tuberculosis. In a summary of 500 cases St. Joseph Sanatorium reports 7 per cent who had definite ulcerative lesion and probably that many more who had infiltrations. Hendricks-Laws Sanatorium reports that 12 per cent of their patients have had some degree of laryngeal tuberculosis.

SYMPTOMS.

A patient with pulmonary tuberculosis who experiences a change in the voice after cough or excessive use, often exhibits

*Presented before the Texas Ophthalmological and Otolaryngological Society, Dallas, Texas, December, 1933.

the first evidence of a laryngeal lesion. If the lesion is confined to the vocal processes there may be little pain; however, a very small lesion of the epiglottis or aryepiglottic folds may produce severe discomfort.

PATHOLOGY.

The earliest lesion to be seen is a slight thickening of the mucous membrane, which appears most often in the posterior commissure or interarytenoid space, and next most often on the vocal cords. The first lesion is an infiltration, then an edematous swelling of the loose tissue, and finally an ulceration. We may also have a perichondritis or a tuberculoma in the larynx. Tuberculosis in the larynx, as elsewhere, begins in the formation of a tubercle, and it is not until the mucous membrane over the tubercle becomes destroyed that an ulcer results.

Pathologists tell us that when the tubercle bacillus comes to rest in a tissue, the fixed connective tissue elements are stimulated, causing a production of epithelioid cells. These cells clustered around a central area are elongated in shape and form the most constant feature of a tubercle. Surrounding these cells is an inflammatory zone of lymphoid cells. In the center of this mass is often found a giant cell, consisting of a large mass of protoplasm containing many nuclei. Such a tubercle is without blood supply and the center undergoes necrosis for this reason as much as from toxins generated by the tubercle bacilli.

Healing may take place by the deposit of calcium salts in the necrotic area and the formation of a dense surrounding capsule, or the entire area may undergo healing by fibrosis, whereby a stimulation of the epithelioid cells changes them into fibroblasts and thus fibrous tissue is formed in sufficient amounts to heal the lesion.

DIAGNOSIS.

In simple catarrhal laryngitis both cords are equally involved and neither ulcerations nor granulations occur.

A tuberculous ulcer is slow in growth, with ill defined margins and no surrounding injection, generally occurring secondary to pulmonary tuberculosis. Healing leaves rather slight contraction and scarring.

A syphilitic ulcer is sharply defined with clean cut edges, and the Wassermann and therapeutic tests are of decided value. Healing leaves a dense scar with contraction and deformity.

Malignancy is not always easy to rule out, but if we have an infiltration limited to the anterior third of one vocal cord in an individual over 40 years of age, who has no pulmonary tuberculosis, we are almost sure of having a cancer to deal with. This is all the more certain if there is a delayed or sluggish movement of the involved cord. Biopsy is positive but dangerous in tuberculosis and in cancer also, unless one is prepared to do the necessary surgery at once.

PROGNOSIS.

Forty years ago Morell McKenzie stated: "It is not certain that any case of tuberculosis of the larynx has ever recovered." Modern treatment has greatly improved that gloomy view, and while tuberculosis of the larynx progresses much in keeping with that of the pulmonary condition, there is many a patient whose larynx has improved while his lungs were growing worse.

TREATMENT.

An early diagnosis goes far in successful treatment, and the laryngeal mirror should be used whenever an examination of the chest is suspicious or positive for pulmonary tuberculosis.

Many early cases recover by rest of voice, together with proper general care. These cases are often greatly benefited by exposure of the larynx to sunlight by means of the metal Verba mirrors. If in spite of this conservative treatment the infiltration increases or an ulcer develops, or if an ulcer is present at the first examination, there is no therapeutic agent known at this time which approaches in effectiveness the electric cautery.

Fetterolf¹ mentions the experimental work done by himself and George B. Wood in 1910 and 1911.

Guinea pigs were inoculated with tubercle bacilli and the resultant lesion cauterized with the electric cautery. It was found that an inflammatory zone developed around the destroyed area, newly formed blood vessels and fibroblasts. In six days the reaction was more marked, blood vessels were more numerous and there were larger deposits of fibrous tissue between the epithelioid cells and

the tuberculous mass. In twenty days the lesions were almost healed. They concluded that anything which aids the cicatrization of a tuberculous nodule by the formation of fibrous tissue is of definite value in the cure of the disease.

When vocal rest and sunlight treatments do not improve the condition Pryor² relies on the electric cautery. He states that most spectacular results are noted in the relief of pain.

Kellam³ states that the specific results following the judicious use of the electric cautery in the treatment of laryngeal tuberculosis bear a similar relation to this complication as insulin to diabetes and arsphenamin to syphilis. He concludes that the electric cautery has largely superseded curets, heliotherapy and acid applications in the treatment of tuberculous ulcers, infiltrations and granulations.

Terry⁴ relies on rest of voice and the electric cautery. He states that disturbing the patient with frequent local applications is as much contraindicated as too frequent removal of a surgical dressing from a healing wound. As a rule, early lesions are healed after a few cauterizations and in advanced cases the excruciating pain is relieved, and at times extensive ulcerations are healed.

Looper and Schneider⁵ state that for the active treatment of the tuberculous larynx they have found the use of the electric cautery most beneficial and employ it in preference to all other methods.

Stephens⁶ thinks that no method of local treatment is so productive of benefit as the electric cautery.

Spencer⁷ states that electric cauterization offers a valuable means of destroying both ulcers and tubercles, and it is doubtful if any method of treatment has yielded better results than the cautery.

Parfitt⁸ states that the judicious use of the electric cautery has proved to be of extraordinary value in healing many cases that do not respond satisfactorily to general and local rest, and also in hastening arrest in recent cases, as well as in reducing pain and soreness, when healing seems unlikely.

Similar opinions have been voiced by Glenn and McGinnis,⁹ Sharp,¹⁰ Muskat,¹¹ Wilkinson,¹² Green,¹³ Looper,¹⁴ Brown¹⁵ Sir St. Clair Thomson,¹⁶ Woods,¹⁷ Briggs¹⁸ and Parish¹⁹.

I have been interested in tuberculosis for twenty years, and have been especially interested in laryngeal tuberculosis during the past ten years. I have tried many of the local applications, such as acetic acid, formaldehyde, chaulmoogra oil, etc., but have never been convinced that any of these were really beneficial. I believe I have benefited some cases by very gently applying a solution of 1 per cent acriviolet in 20 per cent alcohol. This is used two or three times a week in both the cautery and the non-cautery cases.

In the early cases I rely upon the rest of the voice, and occasionally reflected sunlight by means of the Verba mirrors. In all of the ulcerative lesions and in infiltrations which do not show a tendency to improve I use the electric cautery. It has been my experience that most early cases and some far advanced cases are cured, and all are made decidedly more comfortable.

In a list selected alphabetically of 100 private patients suffering from laryngeal tuberculosis, who were seen during the past eight years, I find that forty-eight were in a far advanced and terminal condition when first seen and fifty-two were classed as incipient and moderately advanced.

Of the forty-eight advanced cases only five are known to be living. Two of these cases are well after repeated cauterizations, although at one time practically all structures of their larynges were involved in tuberculous ulcerations. Thirty of these far advanced cases were subjected to the electric cautery, with marked relief of pain in nearly every case. Two cases recovered from extensive ulcerations in the larynx after repeated cauterizations, who later died, one from lobar pneumonia and the other from pulmonary and intestinal tuberculosis.

In the group of fifty-two incipient and moderately advanced cases fifteen had ulcerative lesions and were treated with the electric cautery. The others were treated with rest of voice and sunlight. Of the cautery cases twelve are living and well. Of the other thirty-seven in this group all but four or five are living and have obtained a cure of their laryngeal complications.

This summary shows a cure of 13 per cent of the far advanced cases of laryngeal tuberculosis and 80 per cent of the moderately advanced cases who were treated with the electric cautery.

TECHNIC.

The patient should take no food immediately before treatment, but no preliminary medication is given.

Ambulant patients are best treated in the office, while the very sick are allowed to remain in their beds. The indirect method is just as effective and much easier for the patient.

A 10 per cent solution of cocain is applied to the pharynx and soft palate, and with a curved applicator some of the solution is then applied to the epiglottis. In a few minutes the arytenoids and posterior commissure are touched, and, if the vocal cords are involved, they are also cocainized. As a rule anesthesia is sufficient after ten minutes; if not, more cocain is applied.

For the deeper ulcers and infiltrations a sharp pointed cautery tip is used, and for the broad ulcers a rather flat one. In the first case the cautery is plunged rather deep into the infected area; while in the second, the ulcer is seared rather superficially. The point should be heated almost white hot so the tissues will not stick to it.

It is the reaction to the burn, and not the actual destruction of all the tuberculous tissue that we seek, and for that reason one should be gentle in his manipulations and careful not to do too much at one time. As a rule, we apply the cautery to four or five points, and repeat the treatment from one to three weeks, depending on the reaction. One should avoid cauterizing deeply in the region of the cartilaginous joints, especially the cricoarytenoid, for fear of producing an ankylosis.

As a rule, pain is markedly relieved after use of the cautery, and the patient will request a repetition of the treatment when pain again manifests itself. I feel that the electric cautery is far superior to any other method of active treatment we now possess for laryngeal tuberculosis, and the more its good effects are known the more this valuable therapeutic agent will be used. My greatest difficulty is in getting the patient's physician to refer him to me for cautery treatment before the throat condition is hopelessly advanced.

SUMMARY.

1. Laryngeal tuberculosis is a complication of pulmonary tuberculosis in practically every case.

2. The tuberculous lesion is healed by the deposit of calcium salts in the necrotic areas and by the increase of fibrous tissue which develops from the fixed connective tissue cells, and probably by a changing of the epithelioid cells into fibroblasts. Such healing processes are encouraged by an increased blood supply.

3. Rest is important in all cases of laryngeal tuberculosis. The electric cautery is used in all tuberculous ulcers and infiltrations which do not respond to rest.

4. The electric cautery heals, not by the destruction of all tuberculous tissue, but by the development of an inflammatory zone in which newly formed blood vessels and fibroblasts are produced, which hastens healing by cicatrization.

5. Most early cases heal with cautery treatment, while the advanced cases are relieved of pain.

6. Electric cauterization is a minor procedure, done best under cocaine anesthesia and by the indirect method.

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XLIV.

THE RELATION OF CHEST INFECTION TO SINUS DISEASE.

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Within the space of a few months I had occasion to study two cases of nontuberculous pulmonary disease which had apparently resulted from sinus infection. I am reporting these observations, not because of any unusual features, but because they are typical of a group of cases which have only recently been understood and the importance of the correct interpretation of which is being admitted in wider and wider circles almost daily.

CASE REPORTS.

Case 1.—J. K., a white girl, aged 17, consulted her physician August 15, 1932, because of night sweats, loss of weight and very severe cough. A tentative diagnosis of pulmonary tuberculosis was made and the patient was sent to the hospital for X-ray and further laboratory examinations.

Past history: The patient had had measles, whooping cough, influenza and numerous colds—in her own words: "It seems that I am never free from colds." Tonsillectomy was done four years ago. She suffers from constipation, which is, however, easily controlled. She sleeps well.

Physical examination, September 5, 1932: The patient is a well developed but not well nourished white girl, aged about 17, with a rather sallow complexion. She does not appear acutely ill. The temperature is 99.8 F., the pulse 98. The tonsils have been removed. There is considerable mucopurulent exudate on the posterior pharyngeal wall. There is mucopurulent exudate in the left naris.

X-ray report: Sinuses—There is moderate density in the right ethmoid and right maxillary sinuses. Lungs—The right lung shadow shows considerable peribronchial thickening about the right lower bronchus, extending throughout the right lower lobe. The upper lobes and the periphery of the lungs are normal. This seems to be a nontuberculous condition.

Operation, September 10, 1932: Right ethmoidectomy and opening of the right maxillary sinus. The patient's temperature became normal the day following operation. She was discharged from hospital after two days.

On November 19, 1932, the patient had gained nineteen pounds in weight and the cough had disappeared.

Case 2.—J. F., a white man, aged 27, married, was referred to the clinic for diagnosis and treatment on November 20, 1932. For four months he had been losing weight rather rapidly—he formerly weighed 165 pounds, he now weighed 142. He has a postnasal discharge of several years' dura-

tion and afternoon elevation of temperature; he is afraid that he has tuberculosis.

Past history: The patient has had the usual diseases of childhood, pneumonia six years ago, influenza about four years ago, at which time it is suspected the sinuses may have become infected.

Physical examination: The chest is negative to percussion, but whispered voices are audible over the base of the right lung. The breath sounds are not clear. The heart is normal. The tonsils are infected and embedded. Nasal examination shows a heavy mucopurulent discharge from the right ethmoid.

X-ray report: Sinuses—There is increased density in the right ethmoid and right maxillary sinuses. The sinuses were injected by the displacement method and the sphenoid as well as the ethmoid were shown to be infected. Lungs—The chest shows thickening through the right lower lobe. The apices appear normal. Lipiodol injected into the sinus appeared in the right lung after forty-eight hours; the left lung showed a small amount; the patient sleeps on the right side.

Operation, December 3, 1932: The maxillary sinus was opened and ethmo-sphenoidectomy was done. Within one week of this operation the tonsils were removed.

On February 19, 1933, the patient had gained fourteen pounds in weight. The nose was clean and there was no nasal discharge at this time; he states, however, that he was bothered by a small amount until a few days before this examination.

Recognition that the accessory nasal sinuses are the starting point for many cases of nontuberculous disease in the lungs is of importance to others beside the nose and throat specialist. It is a matter of moment to the pediatrician, since cases of maxillary sinus infection may start in early infancy. Ballou, Singer and Graham¹ cite Paunz as authority for the statement that inflammations and suppurative processes in the paranasal sinuses are known in infants only a few weeks old. Manges² points out that the sinuses drain poorly in infancy, so that infection, once started, tends to keep up. He believes that repeated pneumonia in children is almost invariably attributable to sinus infection when it is not due to unrecognized foreign body in the lung. The type of child who no sooner gets over one cold than he comes down with another and who coughs with every cold ought, decidedly, to be examined for infected sinuses. The cough that has its origin in sinus disease may result directly from a chronic pharyngitis or laryngitis due to the irritating qualities of the postnasal discharge or from secondary infection of the bronchi and lungs. It appears to be established that the so-called diseases of childhood, especially

whooping cough and measles, frequently leave behind them a chronic sinusitis which gives rise to pulmonary changes in adult life. The condition of children's sinuses is well shown in the X-ray picture.

An understanding of this type of pulmonary infection is of great importance also to the tuberculosis specialist. The association of sinus disease with pulmonary tuberculosis is well known, but it now appears not altogether improbable that further experience will show a still more frequent association between sinusitis and nontuberculous pulmonary suppuration. Quinn and Meyer² have observed patients who were treated for tuberculosis over a period of years when in reality their trouble was sinusitis with bronchiectasis. They note that in some instances the sinuses had not even been examined.

The etiologic diagnosis of bronchial asthma will need revision or at least broadening in many cases, in the light of the knowledge of the rôle that may be played by sinus infection in its causation and maintenance. According to Manges,² infection of the accessory sinuses is present in a definite majority of asthmatics, especially children, and in 85 per cent of asthmatics with sinus disease the X-ray examination will show sinus changes in the lungs. McLaurin⁴ believes that bronchial asthma is practically always associated with more or less disease of the sinuses. Admitting the rôle of pollens, animal emanations, food toxins and bacterial toxins as exciting agents, he asks what has sensitized the membranes to these allergins, and thinks that he has found the answer in infection, which diminishes the resistance of the membranes and increase their permeability to the action of foreign proteins.

It is, above all, important that the general practitioner should have an adequate understanding of the part played by sinus infection in bronchial and pulmonary disease, for an examination of the sinuses ordered at the right time—i. e., at the time when an indefinite case with pulmonary symptoms first comes to investigation—will frequently save months of ineffectual treatment, during which the process in the lungs may progress to a stage beyond hope of cure, such as an established bronchiectasis, whereas eradi-

cation of the sinus infection earlier in the condition, in the stage of chronic bronchitis, might have saved the patient from this distressing end-result.

The reason that the sinus involvement must be definitely thought of and sought for is that it is often symptomless, or practically so, at the time that the lung changes have begun to produce symptoms. In a great number of cases some postnasal discharge is the only symptom that would point to the sinuses, and this may be overlooked or misinterpreted. Cough, loss of weight, lassitude are the prominent symptoms; there may be fever. One of our patients had night sweats as a prominent symptom. The manifestations thus belong to the chest rather than to the head side of the picture. Burgess⁵ describes the cough as a paroxysmal, loose, "croupy," productive and finds it "so characteristic of sinus disease that in absence of other obvious causes, it is almost pathognomonic." He also mentions the characteristic odor of the breath, "fetid, . . . between mild diphtheria and bronchiectasis."

The history is important in considering the likelihood of a sinus origin for chest symptoms. A typical history, according to Mullin,⁶ includes frequent and protracted colds in childhood, with marked tendency to cough, or a chronic cough with bronchitis remaining over from one of the acute infectious diseases of childhood. Of thirty-two patients with sinus infection and bronchiectasis, or asthma, whose histories were investigated by Dennis,⁷ ten dated their trouble from an attack of influenza. Several of the diseases of childhood and also influenza were present in the past histories of both our cases.

One or several sinuses may be affected; the maxillary sinus seems to be the one most frequently involved. Mullin⁶ suggests three reasons for the paramount importance of this sinus: (1) The maxillary sinus develops early, being present and subject to infection soon after birth; (2) sufficient aeration and drainage of this sinus are difficult to obtain; (3) this is the largest of the sinuses and hence offers the most extensive surface of lymph spaces for absorption. Lingeman⁸ gives the order of frequency of involvement as maxillary, ethmoid, sphenoid.

The sinus lesion may be suppurative, hypertrophic or hyperplastic. Mullin,⁶ who has given this entire problem painstaking study, states that the hyperplastic is by far the most important form of sinus infection as a factor in the causation of chronic chest infection. The mucous membrane becomes thickened and boggy and ceases to drain through the natural opening. The infection lies in the deep portions, and there is protracted drainage and absorption of bacteria and bacterial products through the lymph channels.

The routes by which infection may travel from the sinuses to the chest are various. Manges² describes three types of lung changes and the mode of invasion which, in his opinion, leads to each of these types. Mullin⁶ has demonstrated that there is direct communication between the mucous membrane of the maxillary antra and the glands at the roots of the lungs. This, Manges thinks, is the principal path of the infection which results in thickening at the roots of the lungs, produced by glanular and other lymphatic enlargement, which is common in chillren and is often diagnosed by clinical and physical signs but rarely considered as resulting from sinus infection.

Direct extension of nasal and sinus inflammation along continuous mucous membrane, first to the pharynx, thence to the larynx, trachea and bronchi, has been shown clinically to be entirely possible. A general peribronchial thickening, such as is a common picture in bronchial asthma, would be the normal result of the widespread and long-standing chronic bronchitis that could be thus induced.

The third mode of invasion is by the air passages, through the inhalation or aspiration of infectious material or the dropping down—"gravity effect"—of such material. In our second case lipiodol injected into the sinus was visible in the lung after forty-eight hours. Jackson⁹ has described the larynx as the watchdog of the lung. But "evidently when the patient goes to sleep it is possible for the watchdog to go to sleep also." Physiologically, as Iglauer¹⁰ admits, nothing can get by the larynx without the patient coughing it up, but "sleep produces partial anesthesia." Iodized oil dropped into the nasopharynx of the sleeper has been

found to go into the lower lobe of the lung (Manges).² This mode of invasion Manges associates with tissue changes in the dependent portions of the lungs and pleura, and especially with bronchiectasis. Both our cases seem to fit well into this category. The chest film showed the thickening confined to the lower portion of the lung, and the lipiodol experiment carried out in one case showed this mode of invasion to be possible in this patient.

These are the three usually accepted routes of infection between the accessory nasal sinuses and the lungs. The hematogenous route may also be mentioned, but is usually held to be more a matter of theoretical than of practical interest for this problem.

McLaurin⁴ thinks that it is deserving of more serious consideration. He points out, further, that the infection may follow more than one route in a single case.

We have been considering the connection between sinusitis and pathologic changes in the lungs in relation to chronic and subacute conditions only. Acute infection of the lung, with lung abscess or bronchial pneumonia, can result from inhalation or aspiration of infectious material from the nasopharynx, and Eadie¹¹ believes he has found evidence of definite association between acute infection of the maxillary antrum and lobar pneumonia. Though the material is small, his evidence is suggestive. In every one of eleven unselected autopsies with postmortem diagnosis of lobar pneumonia, he found acute infection of one or more of the sinuses; in ten the maxillary sinus was infected. He believes that the route taken by the infecting organisms in passing from the sinus into the lung was via the larynx. He recommends investigation of the maxillary sinuses in all cases of lobar pneumonia. If the sinuses are found infected, the earlier they are treated by suction and disinfection, the better will be the prognosis of the pneumonia. Sinus infection is a frequent accompaniment of influenza; hence, in pneumonia following on influenza it would seem to be especially advisable to investigate the sinuses. Eadie recommends attention to the sphenoid sinuses when cerebral symptoms arise in the course of pneumonia.

As to how much influence cleaning up of the infected sinuses may be expected to have on the secondary lung condition, this

will naturally depend very much on the age and extent of the latter. Where the pulmonary lesions are not too far advanced, resolution may be expected. It is just because the lung changes may become irreversible, as in the case of sacculation of the bronchioles in bronchiectasis, that the general practitioner as well as chest, nose and throat specialists are urged to think of the possibility of this connection between infection of the sinuses and of the lungs at a stage when eradication of the source of infection may still avail for cure.

PLAINVIEW SANITARIUM AND CLINIC.

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XLV.

WHY OTOLARYNGOLOGISTS FREQUENTLY FAIL TO REMOVE A FOCUS OF INFECTION.*

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Many physicians are frankly skeptical as to the etiologic relationship between focal infection and systemic disease. A still greater number seriously question whether cure or lasting benefit really follows removal of the focus of infection. This attitude may be due in some measure to disappointment at failure of their patients to be relieved after such supposed removal. Some physicians, impressed no doubt by apparently striking instances of resulting cure or improvement, believe strongly in the causal significance of focal infection and in the remedial effect of its removal. The majority of writers on systemic disease list focal infection under Etiology and its removal under Therapy, although they seldom are enthusiastic about the results to be expected from the latter procedure.

Why is it that so-called removal of the focus of infection frequently fails to cure or relieve a systemic disease that manifestly is due to focal infection? In most instances I believe it is because the real focus of infection has not been removed, due to a misconception as to what constitutes a focus of infection. Billings¹ defined it as a circumscribed area of tissue infected with pathogenic organisms, but the common conception seems to concentrate attention on infected tissue rather than on infecting bacteria.² Thus the otolaryngologist will state that he has eliminated the focus of infection, when what he really means is that he has extirpated infected tonsils or has opened and drained an infected sinus. He does not remove the infecting pathogenic organisms, with the exception of those contained in the excised tonsil or in the washings from the sinus, because infecting bacteria in the upper

*Read by invitation before the Section on Otolaryngology of the College of Physicians of Philadelphia, January 17, 1934.

air passages seldom are confined to a circumscribed area of diseased tissue but are usually present also on adjacent tissues, as may be demonstrated by simultaneous cultures of these adjacent parts. I made seventy-eight pairs of pathogen-selective cultures simultaneously from the tonsils and from the nasopharynx, and found the same infecting organism on both areas in forty-two (54 per cent). Seventy-five simultaneous pathogen-selective cultures were likewise made of the nares and the nasopharynx, and in thirty (40 per cent) the same infecting organism grew up in both. The sinuses and the nasopharynx also were cultured simultaneously according to the same method in nine instances, the same infecting germ appearing in both in three (33.3 per cent). The term infecting organisms is used here advisedly, as the pathogen-selective method of culturing is believed to pick out or select those organisms that are specifically pathogenic for the individual patient.^{3 4 5 6}

In this discussion cases of general or local disease due to endocrine disturbance, to lack of needed vitamins or to allergy not of bacterial origin are definitely excluded.

It is not uncommon for the operating otolaryngologist to leave infected tissue in the nose and throat. When, as occasionally occurs, he fails to remove all of the tonsils, the remaining stumps constitute as great a focus of infection as did the whole tonsil, if not a greater one.^{7 8} Even a perfect tonsillectomy is often followed by a recurrence of tonsillar tissue which may be as serious a focus of infection as was the original tonsil.⁹ The lymphoid masses, commonly spoken of as recurrent tonsils, but which are infratonsillar lymphoid tissue that has worked its way upward into the empty tonsillar fossæ,^{9 to 17} are regarded by French¹⁰ as quite as potent a factor of systemic infection as infected faucial tonsils, the same micro-organisms being recovered from both.

What is not so well known, however, is the fact that normal-appearing tonsillar fossæ may harbor the same infecting organisms that were present in the extirpated tonsils and thus may act as bacterial foci of infection. In one-half the throats of which I made pathogen-selective cultures both before and after tonsillectomy—in several cases after an interval of five years—the chief infecting germ was the same in both cultures.

Infecting organisms will also usually be found in the tonsillar fossæ of tonsillectomized individuals who still suffer from upper respiratory infection. I took seventy-four pathogen-selective cultures of apparently normal tonsillar fossæ in patients suspected of infection of the upper air passages and found infecting bacteria in seventy-three (97 per cent). Of 305 pathogen-selective cultures made of the tonsillar fossæ and the nasopharynx together, also in patients with upper respiratory infection, infecting organisms grew up in 283 (93 per cent).

After adenoidectomy by skilled surgeons tags and remnants frequently are left in the nasopharynx, where they persist as foci of infection.¹⁸

An apparently normal nasopharynx, however, may act as a bacterial focus of infection, as I pointed out some years ago.¹⁹ I made 147 pathogen-selective cultures of the nasopharynx in patients with suspected upper respiratory infection and found infecting germs in 140 (95 per cent).

When after an operation the infecting microbes persist in the infratonsillar lymph tissue, in the tonsillar spaces, in the nasal passages, in the sinuses or in the nasopharynx, where they continue to multiply and elaborate toxins and infect distant tissues and organs,²⁰ how can one believe that the focus of infection has been removed? I regard therefore as of little value the many published comparisons of tonsillectomized and untotomized persons. For, if the infecting organisms are still present in the tonsillar spaces or in the nasopharynx, why should one expect the tonsillectomized group to be freer from disease? Otolaryngologists who are dissatisfied with the results of sinus treatment and operation^{21 to 25} apparently do not realize that the failure to cure by conservative or radical measures may be due to persistence of the infecting organisms. I made 230 pathogen-selective cultures of the nares and thirty-five of the sinuses in patients who had received expert treatment for sinusitis, and found 180 (78 per cent) of the nasal cultures and 20 (57 per cent) of the sinus cultures to contain infecting organisms.

If our conception of focal infection stressed the bacterial element and regarded the causal germ as the chief infecting agent,² we could more readily conceive of this purely bacterial focus of

infection existing in the absence of recognizable diseased tissue and produced solely by infecting organisms living on an apparently normal mucous membrane.²⁰

There is no question that many patients, following treatment or operation, do recover both from their upper respiratory infection and from the secondary systemic disease. This is not because the infecting germs have been removed by the surgeon, but because they have been overcome by the patient's defensive forces. The operation removes infected tissue containing large numbers of infecting germs which have found this tissue a favorable soil for their growth, and also removes mechanical obstructions to proper aeration and drainage. Following this the patient may regain his lost power to produce bactericidans and other antibodies in sufficient quantity to destroy the infecting bacterial focus of infection. Indeed, in cases of combined tonsillar and sinus infection the lessening of the immunologic strain through the removal of the tonsils may result in Nature's cure of the sinusitis. On the other hand, an operation may lower resistance still further, with consequent increase of symptoms or further extension of the infection.

In my personal experience, increase of bodily resistance seldom follows local treatment or operation without further medical aid. A similar situation must have been recognized by Billings, who recommended not only removal of all primary and, if necessary, all secondary foci of infection, but also the building up of the natural defenses of the body.²⁰

Some cases need only the institution of hygienic measures, such as fresh air, sunlight (real or artificial), proper food, proper bathing and proper clothing, sufficient exercise, recreation, rest and sleep and regulation of mental and physical work.

Others may be aided further by the administration of appropriate drugs and the application of indicated procedures of physiological therapeutics. Many patients, however, require in addition the artificial stimulation of specific antibody production by means of a proper vaccine.

This brings up another subject about which there is considerable controversy. Most physicians regard vaccine therapy as worthless or as of little value. I am somewhat in agreement with

this view with respect to the use of stock vaccine and of most autogenous vaccines in subacute and chronic infections. The employment of vaccines in acute infections and for prophylaxis is excluded from consideration in this discussion. My chief objections to ordinary autogenous vaccine in subacute and chronic infections are that it may fail to contain the infecting organism, it seldom contains their soluble exotoxins, and its antigenic power frequently is feeble.

In a subacute or chronic infection the mere presence or even the profusion or predominance of a germ in or on an infected tissue or in the secretion or excretion from it is no indication of any etiologic relationship between such micro-organism and that infection. Indeed, such a microbe may even be nonpathogenic for the patient, as I have repeatedly shown.^{3 10 6} Yet it is from just such bacteria that most autogenous vaccines are made. The predominating organism in 384 cultures I made in Rosenow's brain broth was capable of infecting the host in only 215 (56 per cent) and was nonpathogenic for him in 169 (44 per cent). Moreover, in over 10 per cent of all cultures in Rosenow's brain broth, as Boerner and I have shown,⁶ the infecting organism fails even to grow up. This I attribute to its being in small numbers in comparison to the large number of organisms present which are nonpathogenic for the patient and which overgrow it.⁵

The principal objection of most physicians to vaccine therapy in systemic diseases, believed to be due to focal infection, is the difficulty, if not the impossibility, of determining what germ is the cause of the disease and which, if any, of the bacteria at the supposed primary focus is the etiologic one. For determining this a number of methods have been devised, utilizing improved technic, differentiating media, animal passage, tests for the bactericidal power of whole blood and for hypersensitiveness, and serologic tests, including agglutination, precipitation, hemolysin, absorption and complement fixation tests. Only three of these are mentioned by Kolmer and Boerner in "Approved Laboratory Technic." The complement fixation test is described without comment.²⁷

Of intracutaneous skin tests the authors say: "Positive skin reactions may be an indication of acquired allergic sensitization

and therefore evidence of infection with the organism; but they may be also plain inflammatory reactions if the inoculum contains a toxin or toxins for which there are no or insufficient amounts of antigen in the blood. The exact value or status of the method is as yet unknown."²⁸ Eiman states that by intradermal testing we often find response to organisms not judged etiologic by the pathogen-selective method and that if there is an intradermal reaction, the individual does not contain antibodies for that organism.²⁹ In a recent study I came to the conclusion that there probably is no relationship between hypersensitiveness in the host to the exogenous and endogenous toxins of a given organism and the pathogenicity of such organism for that host, that consequently it is questionable whether in a mixed culture intracutaneous tests can identify the bacteria that are infecting the patient, and that therefore intracutaneous tests are probably unreliable for selecting bacteria in the preparation of vaccines.³⁰

The pathogen-selective method is described in detail by Kolmer and Boerner, who state that it aims to prepare autogenous vaccines mainly of organisms found capable of growing in the whole coagulable blood of the patient on the assumption that these are most pathogenic for the individual.³¹ One of its advantages is that it furnishes a means for selecting the etiologically important organisms from a mixed culture. Another is its simplicity, which makes it easily available for clinical use. It has been widely employed with success by Lowe^{32 33} of Liverpool, Crowe^{34 35} of London and others. It would seem to fulfill the requirements of Wood³⁶, who complains:

"How can the average man tell when an apparently normal sinus contains a vicious type of infection? Cultures do not help much. Injection into animals is almost as useless because a micro-organism to which one species is naturally immune may kill another species. Even in different individuals of the same species one strain of bacteria may grow and thrive as a harmless parasite to one host, but when transmitted to another proves fatal. No matter what biologic characteristics the cultures may show, how can one determine when they are virulent for the particular individual if they do not show evidence of local inflammation in the area which they have selected as their abode? What is needed

is real tangible evidence that can be applied as a useful aid in diagnosis."

In order to obtain the infecting germ it is necessary to culture the principal foci. Several methods have been devised for determining which of several suspected areas is the primary focus of infection.

Lowe³² utilizes the pathogen-selective culture to differentiate between foci in the same patient, and to indicate those which contain organisms that are pathogenic for the patient and those which are only of local infective importance. He believes that such positive pathogen-selective cultures when obtained from dental, tonsillar or sinus material indicate the need for radical removal of such a focus of infection, if this is clinically possible. Negative pathogen-selective cultures suggest to him that the focus of infection from which the specimen was collected, while probably requiring local treatment, is not causal of systemic infection if such exists.

Ramsay and Pearce³⁷ have tried to arrive at a more accurate estimate as to the normality or otherwise of a tonsil by means of direct puncture into its substance, with subsequent pathogen-selective culturing of the aspirated material. If the immunity of the blood to the organisms obtained is found to be impaired, they believe that removal of the tonsils is probably desirable, other things being equal.

French utilized tonsilloscopy to assist in determining when tonsils are seats of infection, and in what way and to what extent.¹⁰

My own practice is to take pathogen-selective cultures of all areas that might possibly be foci of infection rather than to concentrate on a single focus. When culturing the upper respiratory tract, therefore, I always include both nares or certain suspected sinuses, both tonsils or tonsillar fossæ, and the nasopharynx, in this way obtaining infecting germs that are present in one area and not in another.

That adjacent areas may harbor different organisms is shown by my simultaneous cultures of neighboring parts. Of the seventy-eight pairs of pathogen-selective cultures of the tonsils and nasopharynx none of the bacteria infecting the tonsils were found

in the nasopharynx in eighteen (23 per cent), while none of the infecting germs in the nasopharynx was present in the tonsils in eighteen (23 per cent). Of the eighty-one simultaneous pathogen-selective cultures of the tonsillar fossæ and nasopharynx none of the infecting microbes in the nasopharynx was discovered in the tonsillar fossæ in twenty-two (27 per cent), and none of the infecting germs in the tonsillar spaces were present in the nasopharynx in twenty-one instances (26 per cent). Of the seventy-five pairs of pathogen-selective cultures of the nares and nasopharynx none of the infecting germs in the nares was found in the nasopharynx in twenty-one (28 per cent), and none of the infecting germs in the nasopharynx was present in the nares in twenty-four (32 per cent). In three (33.3 per cent) of the nine pairs of simultaneous pathogen-selective cultures of the sinuses and the nasopharynx none of the infecting organisms in the sinus was present in the nasopharynx, and in three (33.3 per cent) none of those in the nasopharynx was found in the sinus.

It is important not to omit any of the infecting organisms from the vaccine lest the latter lack antigenic power for necessary antibodies and thus prove ineffective.

Even when all the infecting germs have been included in the vaccine, its therapeutic value may be slight unless, in addition to the endotoxins present in the bodies of the bacteria, it contains the soluble or exogenous toxins which the germs have elaborated outside their bodies during their growth. Some physicians employ only these soluble toxins. While the latter may be more important for desensitization in conditions of pure bacterial allergy, I believe that the vaccine should contain all the required antigens to insure the production of therapeutically valuable antibodies. These requirements are fulfilled by the pathogen-selective vaccine, which consists of the killed organisms together with the hormone broth medium in which they have been cultivated for four to five days, as suggested by Kolmer.³⁸

Owing to its high potency, the pathogen-selective vaccine must be administered with the greatest care. The dosage sometimes must be one-billionth or one-trillionth of that ordinarily employed in vaccine therapy. I have given as small a dose as one-

quintillionth of a cubic centimeter, corresponding to one-billionth of a germ. A serious sinus flare-up, an exacerbation of the systemic disease, or a decided increase in symptoms and toxemia, may be produced by a dose that is too large for the individual patient. Distinct improvement, however, usually follows the optimum dose. This is attained by estimating the initial dose from the effect of an intracutaneous test with .05 cc. of the undiluted or diluted vaccine and by determining all subsequent dosage according to the general, focal and local reactions produced by the immediately preceding dose.

Skillful administration of a properly prepared pathogen-selective vaccine, supplementing the work of the otolaryngologist, frequently results in the complete eradication of primary and secondary foci of infection with cure of both the local and the systemic disease and disappearance of the toxemia. When associated with conservative local treatment, in cases of sinusitis, it will often render radical operative measures unnecessary. Several doses preceding nose and throat operations in cases with greatly lowered resistance may produce sufficient antibodies to prevent exacerbations of symptoms and to promote healing.

SUMMARY AND CONCLUSIONS.

1. The impression that the otolaryngologist can remove a focus of infection is based upon the common misconception of a focus of infection, which concentrates attention on infected tissue rather than on infecting micro-organisms.
2. When the otolaryngologist states that he has removed all foci of infection from the upper respiratory tract, what he really means is that he has extirpated infected tissue or has opened, drained and washed out an infected cavity.
3. Following operation the infecting organisms present on adjacent tissue may continue to live, multiply and elaborate toxins, with the formation of a purely bacterial focus of infection, which is able to keep up the secondary systemic disease.
4. Recovery occurs only when the infecting germs and their toxic products have been overcome by the patient's defensive forces.

5. The production of bactericidins and other antibodies, to destroy the infecting bacteria and render their toxins harmless, is furthered by removal of infected tissue with large numbers of contained infecting organisms, which had found it a favorable soil for their growth, and by the removal of obstructions to proper drainage and aeration; it is increased by hygienic measures; and it may be stimulated artificially by a vaccine which should contain both the exogenous toxins as well as the endotoxins of the infecting bacteria.

6. In a subacute or chronic infection the mere presence or even the profusion or predominance of a micro-organism in or on an infected tissue or in the secretions or excretions from it is no indication of any etiologic relationship between such micro-organism and the infection. Yet it is from such organisms that most autogenous vaccines are made.

7. The chief objections to ordinary autogenous vaccines in subacute and chronic infections are that it may fail to contain the infecting germ, it seldom contains their soluble toxins, and it frequently has feeble antigenic power.

8. The pathogen-selective culture, which is simple and easily available for clinical use, furnishes a means for selecting the etiologically important organisms from a mixed culture.

9. Pathogen-selective cultures of the nares or sinuses, the tonsils or tonsillar fossæ, and the nasopharynx probably will contain all the infecting organisms in the upper respiratory tract.

10. A vaccine consisting of a broth culture of these germs will contain the soluble exotoxins elaborated during their growth as well as the endotoxins present in their bodies.

11. Owing to its extremely high potency, the pathogen-selective vaccine must be administered with the greatest caution. The dose may have to be as low as one-trillionth of a cc. of a suspension consisting of one billion organisms in each cc.

12. With its skillful administration, supplementing the work of the otolaryngologist, it is possible in many instances to completely eradicate the primary focus of infection and to cure or relieve the systemic secondary disease and toxemia.

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XLVI.

A NEW TREATMENT FOR EUSTACHIAN TUBE OBSTRUCTION: CONTROLLED HEAT BOUGIE.

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Of the various methods of treatment used today in chronic catarrhal otitis media, ventilation of the middle ear seems to be most effective. Sir Dundas Grant¹ writes: "In a recent discussion on the subject it was generally agreed that the condition known as chronic nonsuppurative catarrh of the middle ear (excluding otosclerosis) consisted mainly in the changes resulting from catarrhal narrowing of the eustachian tube; and the most helpful line of treatment, while not overlooking the catarrhal factor, was to overcome the narrowing at as early a stage as possible." Essentially, it is recognized that obstruction of the eustachian tube impedes ventilation which in turn causes decreased hearing, tinnitus, etc. In the treatment of chronic catarrhal otitis media ventilation or opening of the obstructed eustachian tube with aeration of the middle ear has been the most effective means.

Politizerization, catheterization with inflation, and the valsavala method are all used apparently to dilate the strictured or thickened mucosa of the eustachian tube. It is difficult to conceive how compressed air, as used in these procedures, can possibly dilate the mucosa enclosed by a rigid tube without rupturing the thin unsupported drum membrane. Bouginage and its modifications, such as Yankauer applicators or Duel's electrolytic bougie, would seem to be more effective because of the principle involved. It is a common conception that one passes a sound or bougie into the strictured eustachian tube for the purpose of stretching or tearing open this constriction. The modern view of the theory of sounds is that in their passage into the body they act as foreign bodies, irritating the tissues and producing hyperemia. This hyperemia is temporary, but such as it is, is the agent of repair. By constant gentle irritation one hopes to increase the blood supply to the dis-

eased tissue, for this is the agent which is the healer par excellence. In addition, the hyperemia causes swelling of the tissues which surround the sound; the sound itself cannot be decreased in diameter, with the result that the tissues swell or stretch themselves on the form, and one can feel the enlargement on withdrawing the bougie.

I wish to offer a bougie—a heat bougie which I have been using for over two years. This bougie is used with the standard catheter and comes in graduated sizes, the smallest being 2.5 to 3 french in diameter—i. e., about the size of the No. 2 whalebone bougie (See Fig. 1). It has a resiliency slightly more than the Yankauer applicator and slightly less than the whalebone ones. The bougie internally consists of two separate well insulated circuits: (1) Composed of fine resistance wire through which a low grade current runs from a control rheostat furnishing any desired heat up to about 180° F.; naturally one does not use sufficient current to produce this high degree of heat. (2) Consists of a circuit with a thermocouple in the distal portion of the bougie which serves to continuously register the temperature of the mucosa with which it is in contact. As most doctors know, a thermocouple is a scientific electrical apparatus for recording temperature where thermometers are not efficacious. It must be understood that when the bougie is in the tube the reading of the thermocouple “thermometer” is not simply the temperature of the heat in the resistance wire. It is the resultant or combined temperature of this wire, which is trying to increase the temperature in the surrounding mucosa; and the mucosa which has a lower temperature and is trying to absorb and lower the temperature in the resistance wire. These different elements finally reach an equilibrium, and every element involved reaches this “balanced” temperature. In short, it is the actual temperature of the heated mucosa lining the tube. It is this temperature, registering continuously and automatically, that I call the control mechanism of the bougie, and which has delayed presenting this heat bougie for almost two years. Originally this heat bougie was used with the heat wire only and a so-called heat control in the external circuit—i. e., outside the bougie. However, I was convinced by engineers that this type of temperature control was highly inaccurate, and

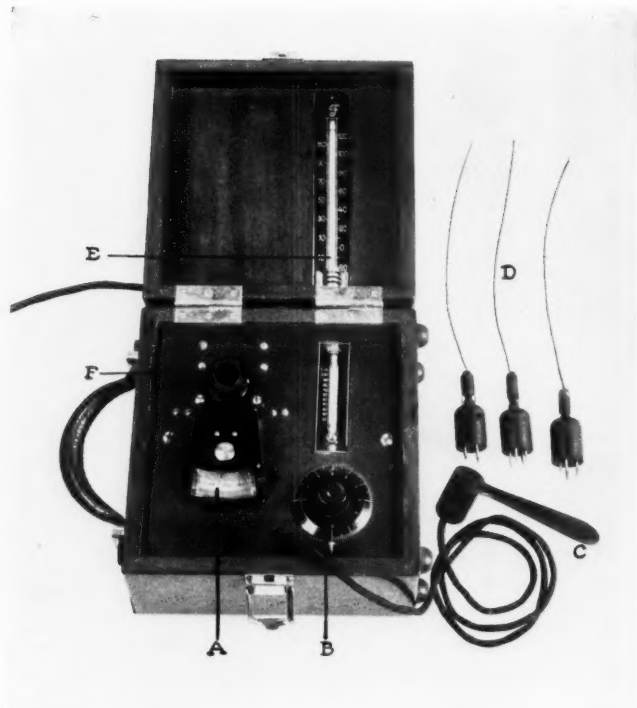


Fig. 1. Controlled eustachian heat bougie apparatus: *A*—galvanometer "thermometer"; *B*—heat regulator; *C*—patient's handle; *D*—bougie sizes 1, 2, and 3; *E*—room thermometer; *F*—knob to set galvanometer.

I can state that this is absolutely so. For instance, if the temperature of the bougie is set to furnish a temperature of 110° F. in air (so-called external control), the actual temperature of the tubal mucosa from this heat would be about 100° F. Again, if set to give 120° F., the mucosal heat would not reach 105° F. in the average case. Finally, if set to furnish a temperature of 140° F., it reaches in the average case about 110° F. This discrepancy depends on several factors besides the degree of temperature of the source, viz.: (1) The amount of surface of the heating source;

(2) the amount of surface to be heated; (3) the heat conductivity of the particular tissue; (4) the moisture present in the tissues.

I have been unable to find any reference in the literature to a heat bougie combined with a thermocouple for indicating the temperature of the heated tissues. As far as I am aware, this is the first time that such a combination has been used anywhere in the body. An accurate temperature control is essential in heating tissues if one is to avoid injuring or burning of the mucosa, especially in the eustachian tube. As well as I can determine, there seems to be no sensory ending for heat in the eustachian tube, and

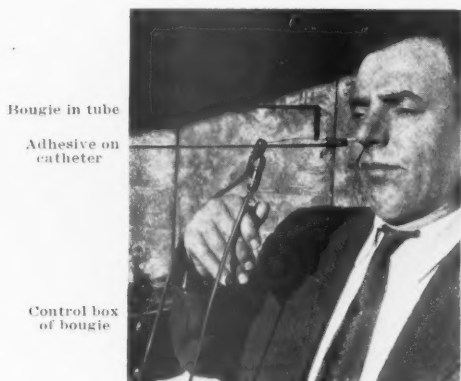


Fig. 2. Controlled eustachian heat bougie apparatus in use.

I was unable to ascertain this question from the literature. The bougies may be heated to a high degree, and the patient will not complain of any pain or burning sensation. Some of the heat is conducted from the bougie to the catheter and the "dry" skin at the vestibule of the nose may become sensitive to this heat. To avoid this I have put a single layer of adhesive on the catheter where it crosses the vestibule of the nose. (See Fig. 2.)

The only report that I could find of heat used in the eustachian tube is by Beck,² and who in a personal communication wrote: "I have used them (heated bougies) by employing metal bougies of the kind that Dr. Arthur Duel of New York recommended in

ordinary dilatation and attaching them to the medical diathermic current."

The procedure used with these heat bougies was varied slightly at different times, but essentially it is: Insertion of the bougie through a short (Yankauer) catheter. Then turning on the heat gradually at the rheostat dial until the galvanometer of the thermocouple reads 110° F. This temperature is maintained for a period of ten minutes, following which the heat was completely turned off but the bougie is still left in the tube. After ten minutes the "cold" bougie is withdrawn. This procedure was usually done weekly. As with any bougie, one can feel the passage into a narrow or strictured tube and on removal of the bougie there is a distinct sense of roominess in the tube along with some free mucus. As mentioned above, widening of the tubal lumen commonly follows with the use of any bougie. With the heat bougie there is in addition a more lasting and effective dilator of the tube, namely, a heated form. When the heat is turned off the swollen mucosa around the bougie becomes decongested and shrinks away from the form and the lumen of the tube has actually widened itself. Furthermore, we have increased the blood supply to the local tissues, at least momentarily, both from the irritation of the bougie and from the heat. On inserting the bougie into the tube one may take its temperature, which usually runs about 99° F. After the bougie has been maintaining a temperature of 110° F. for ten minutes or more, one may occasionally notice a slight drop in the galvanometer to 108° F. This is due to one of two factors: First, the irritation of the bougie has increased the amount of tubal mucus, which will lower the temperature, and secondly, the cord connectors may have been held too near to the face and were being warmed by the patient; this alters the reading slightly. If the patient is swallowing a lot of mucus, increase the amount of heat; if not, it is probably due to the latter cause and one lets the heat alone and has the patient hold the cord connector further away from the face. When the heat is completely turned off, the temperature immediately drops to below 99° F., sometimes as low as 90° F. I think this is due to an excess of mucus produced by the irritation of the bougie and the heat. The apparatus is simple and can be readily regulated by an average nurse.

There are some otologists who believe in little treatment of the eustachian tube in adults with loss of hearing. Shambaugh⁸ thinks that tubotympanic infections are responsible for but a limited number of cases of marked loss of hearing in adults. He believes most of them are due either to otosclerosis or to long continued neuritis of the cochlear nerve and says: "Occasionally the tubal occlusion does produce a permanent, rather serious, form of deafness; but this occurs only occasionally." He also writes:⁴ "Clinical experience has shown that tubotympanic processes, which occur with such frequency in early childhood producing permanent alterations in the membrana tympani very often leave no permanent disturbance in hearing." He feels most cases of adults with severe degree of loss of hearing are due to otosclerosis and that these cases receive too much intranasal treatment, including bougies, in the eustachian tube. And that in progressive loss of hearing in adults who have had a previous otitis media that at times there is a concomitant but distinct entity of otosclerosis.

In contrast to this view, Dan McKenzie⁵ has used the term "secondary otosclerosis," which he briefly explains in the following: "Further, as we shall see in a moment, the otosclerosis syndrome may be evoked by scar tissue formation in the middle ear without any osteoporosis." I think, even from my limited experience, that it is extremely difficult to make a differential diagnosis of otosclerosis in a patient who has had otitis media.

As to the therapeutic value of the heat bougie compared to other methods, I think the heat bougie will open the most rigid stricture, will keep the tube open longer and with less frequent treatment than any other procedure mentioned.

There were some patients who complained of tinnitus and loss of hearing, in whom there was no improvement of the hearing but who were relieved of tinnitus. These were fairly common and usually occurred in the more advanced cases.

If the inflammatory process is limited to the tube it will certainly improve the hearing and tinnitus, and this is the result we have obtained in such cases. If the process has gone on into the middle ear it will help the patient if there are no adhesions and fibrosis. However, if there are scar tissue and adhesions there

usually is some involvement of the stapes, often with some fixation. We have definitely improved hearing in some of these cases with a fixed or adherent drum, but in general the outlook is unfavorable. As mentioned, we have very often relieved this type of tinnitus without any betterment in hearing. In cases of chronic catarrhal otitis media there is little to be expected from inflation, whether it be valsalva, politzerization or via catheter. They do not open the tube; at their best they may give some temporary relief. The heat bougie in this type of case is most effective, I think, and requires less frequent introduction than any other bougie or modified bougie.

In acute catarrhal otitis media or tubotympanic catarrh I prefer waiting two weeks before using the heat bougie. If there is no improvement in two weeks, I feel that it is time to try to open the tube and have done so. The results in this type of case are most striking. The patient does not feel the relief immediately following treatment as in inflation. It takes about twelve to twenty-four hours before he notices any relief. The irritation and heat of the bougie produce an excess of mucus, which fills the canal for a short time, even though the tube itself is open more than usual. Some patients have had complete relief in one treatment; others note a lessening of fullness in the head with some crackling in the ear on blowing the nose with alternate periods of relief from the fullness and ringing. In these last cases it means more treatment is needed.

We have also used the heat bougie in cases of acute discharging ears of three or more weeks' duration. It has stopped the discharge in a high percentage of cases by permitting drainage through the tube.

All of the untoward reactions in over 400 treatments consisted of two cases, in each of which a stricture was produced from overheating. These happened early in the work and both were thoroughly opened. Also, the very first case in which the heat bougie was used the bougie was put in about 40 mm. I wanted to make sure that the bougie, which was not graduated, was in the whole length of the tube. After the heat was on for about a half minute the patient complained of being very dizzy and nau-

seated. I had undoubtedly been heating the middle ear and the semicircular canals. The heat was turned off and the bougie withdrawn for about 5 mm. The heat was then put on, and the treatment went along without any further mishap. Since then I put the bougie in for 35 mm. and the above experience has never occurred.

CONCLUSION.

1. The heat bougie will open the most rigid stricture; will keep the tube open longer, and with less frequent treatment than any other procedure I know.
2. The danger in using the heat bougie is negligible and with average attention is nil.
3. In my opinion, it is the best procedure in cases of acute catarrhal otitis media, of two or more weeks' duration; in chronic catarrhal otitis media it will give more improvement than any other treatment; in the acute purulent type of three or more weeks' discharge it frequently permits drainage through the tube with cessation of the discharge; in chronic purulent otitis media the results have been only fair.

238 LARK STREET.

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Clinical Notes and New Instruments.

XLVII.

MASTOID INFECTION AND NUTRITIONAL DISTURBANCES IN INFANTS: REPORT OF THREE CASES.*

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This subject has been of interest to me for the past seven years. During that time quite a controversy has been waged and a mass of literature has accumulated. The profession has become sharply divided into two schools—one claiming that there is no relation between mastoid infection and nutritional disturbances; and the other holding that the infection within the mastoid is the dominant factor in the malnutrition and the direct cause of the accompanying diarrhea. Many writings and discussions have been bitter; and zealous advocates of each side have dug in, and refused to listen to opposing argument. This attitude is unfortunate, for there is no problem in medicine where an open mind is more to be desired.

Those who hold that there is no relation between mastoiditis and nutritional disturbances in infants have based their arguments largely on lack of clinical results in a group of selected cases. Most of these reported cases have been the acute, fulminant, "cholera infantum" type, where one would have to be extremely optimistic to expect results from any form of treatment. Because of the lack of universally good results in this group of cases, they have denied any relation between the two conditions in spite of many cases reported by reputable men where excellent results have followed mastoidectomy. They have completely ignored the findings of the pathologists^{1 2 3 4 5} who have carefully opened the mastoids of infants dying of nutritional disturbances. As far as

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I know, there has never been reported an impressive series of these cases where definite infection within the mastoid has not been found in a considerable proportion.

The infantile mastoid process is poorly developed, but the bony middle ear and antrum by actual measurement⁶ are as large as those of an adult. Also, although there is little cellular development, the bone contiguous to the antrum is cancellous and susceptible to infection just as the petrous apex^{7 8 9} has been shown to be. Therefore the mastoid antrum and contiguous infectable bone in these tiny patients is relatively as large as that in older persons in whom profound systemic effects¹⁰ may accompany mastoiditis.

I do not believe that any position is tenable which completely disregards these pathologic considerations or the clinical results following mastoidectomy in cases similar to the three I am reporting.

On the other hand, clinical results in the hands of various experienced operators do not justify indiscriminate operation on the mastoids of every baby with ear infection and nutritional disturbance. The theory that a toxin is elaborated by the diseased ears having a peculiar affinity for the gastrointestinal tract has not been generally accepted. Middle ear infection can hardly be considered as the sole cause of diarrhea. Severely ill patients with undoubtedly some involvement of the mastoid may recover under medical management alone. Nevertheless, I am thoroughly convinced that many cases die that might have been saved had their mastoids been operated upon. The exact nature of the relationship between the ear infection and the nutritional disturbance is problematical. It is a well known fact that infections of the upper respiratory tract are very prone to occur in individuals with lowered general resistance. On the other hand, it is as equally well established clinically that chronic tonsillitis or an acute attack of tonsillitis may be responsible for recurring attacks of gastro-enteritis with malnutrition in older children. Consequently, the sane view to take of the mastoids is that they are simply potential foci of infection. The classical symptoms of mastoiditis do not present because the infant's resistance is so low that he is not capable of producing much local reaction. I believe that the question of which is the cause and which the effect

is purely an academic one; but that once definite infection within the mastoid has become associated with grave nutritional disturbance a vicious circle is established. The child cannot get rid of the gastro-enteritis or gain weight because of the infection within the mastoid; nor can he conquer the infection because of his lowered resistance. If the circle can be broken—medically by increasing his resistance to infection or surgically by eliminating the focus of infection—he will recover; if not, he probably will die.

In the three cases reported in this paper, your attention is invited to the fact that in none was surgery resorted to before the effect of medical treatment could be determined. Rather every effort was made to build up the child's general resistance by intensive general therapy, including repeated hypodermoclyses and transfusions. This line of procedure was followed until it was established beyond reasonable doubt that the child would not recover on this regime alone. There was no change in pediatric management after operation; so that the striking improvement in every case can be directly attributed to the removal of the focus of infection within the mastoid.

REPORT OF CASES.

Case 1.—J. C., a 10 months old girl, entered the hospital August 2, 1932, with the story of frequent (ten to thirty daily) stools for ten days. These had been watery with some blood and mucus. There had been no vomiting.

She had been a full-term baby, weighing seven and one-half pounds at birth and seventeen and one-half pounds prior to the present illness.

The past and family histories were unessential.

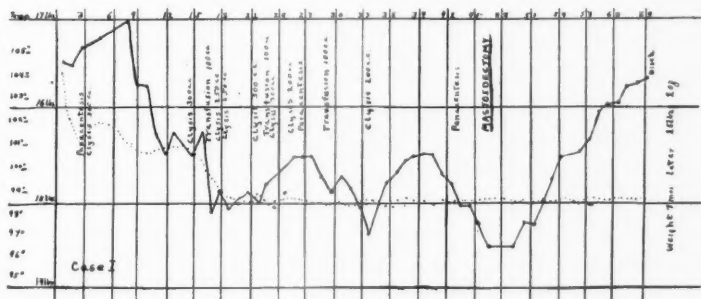
Physical examination was negative except for dehydration, red throat and red tympanic membranes.

Laboratory study showed some leucocytosis and a pyclitis of moderate severity. Cultures of the stools were repeatedly negative for typhoid and dysentery.

Her progress in the hospital has been charted graphically. The baby had to be tube fed constantly until after mastoidectomy, when she began taking food spontaneously. The temperature gradually dropped to normal by the end of the third week and remained so. There did not seem to be any relation between the ear infection and the temperature. The pyclitis cleared up satisfactorily on urotropin. She developed a marked pylorospasm, for which abdominal surgery was seriously considered, but which subsided rapidly following mastoidectomy. The usual shifting and reshift-

ing of the feeding formula was done prior to the operation, after which she was placed on the usual formula for her age. There never was any definite sagging of either canal wall. The ears discharged intermittently, requiring repeated paracenteses. The tympanic membranes never appeared normal until after mastoidectomy. Although there had been considerable and constant trouble in both ears, and the X-ray was suggestive of an equal, indefinite involvement of both, the left ear had been worse clinically. It was decided to operate upon that mastoid alone. Local anesthesia was used. Definite pus was found in the antrum, and some of the much discussed material resembling granulation tissue.

Recovery after operation was rapid and uneventful. The patient has since been followed in the outpatient department, and has continued to do well. When last seen, May 3, 1933, she weighed twenty-five pounds and two ounces.



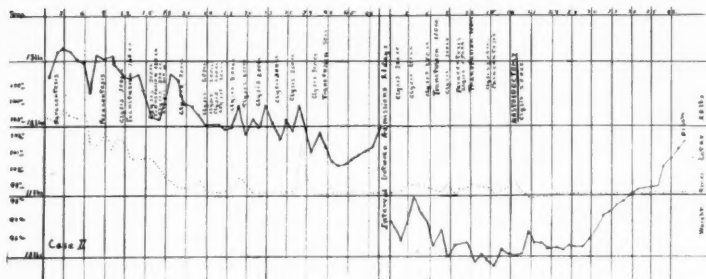
Two sibs had bone tuberculosis. Otherwise the family history was of no interest.

Physical examination was negative except for temperature, marked dehydration and red ear drums.

Laboratory examination showed a pycitis, which cleared up under appropriate treatment, and a leucocytosis of 28,000. Stool cultures were repeatedly negative for typhoid and dysentery. Tuberculin tests were negative.

The chart shows her progress while in the hospital. Two days after admission both middle ears were opened and pus released. After this they had to be opened on several occasions. After fifty days of intensive medical treatment the diarrhea had been checked, and the ears had been dry for several days. She was gaining in weight and was sent home.

Three weeks later she was readmitted with a history of prompt return of the diarrhea after leaving the hospital. The diarrhea had not been as severe as on the previous admission—six to eight stools daily without blood. General examination was about the same as last time except that



during the interval she had lost one pound and six ounces of weight. The tympanic membranes were red but not bulging. Ten days later they were both bulging and were cut, with a discharge of pus from each side. Five days later they had to be reopened. X-ray of mastoids at this time was reported, "bilateral mastoid pathology: processes on each side filled with exudate or granulations." In spite of intensive pediatric management the baby was steadily losing ground and mastoidectomy was decided upon. On September 6th, under local anesthesia, both mastoid cavities were opened, and pus and granulation tissue found. Following this her condition remained stationary for ten days, when she began to gain weight rapidly. Twenty-six days after mastoidectomy she had gained one pound ten ounces in weight and was discharged.

She has been followed in the outpatient department since discharge and has continued to do well. There has been no further ear trouble or diarrhea. Her weight on July 27, 1933, was twenty-three pounds and four ounces.

Comment.—Including the twenty-three day interval at home, this child was treated medically for three months prior to operation. This treatment

included twenty-one clyses and five transfusions. At the end of this time she had lost three pounds and six ounces, or 25 per cent of her admission weight. One month after mastoidectomy she had gained almost two pounds. During this time there had been no transfusions and only one hypodermoclysis. During the entire time she had been under the same pediatric management.

Case 3.—V. M., a 7-months-old female, was admitted to the hospital February 2, 1929. She had had a cough, dyspnea and high fever for ten days. There had been a slight head cold but no ear symptoms. She had had no vomiting or diarrhea.

Past history: Had "flu" three months prior to admission. At this time she had been ill for three weeks and lost considerable weight. She had always been a troublesome feeding case.

Family history: She was an illegitimate child. The father was living and well. The mother was very frail and coughed a great deal.

P. Ex.: She was emaciated, dehydrated and appeared to be gravely ill. There was a rickety rosary on her chest.

There was impaired resonance over her right upper thorax anteriorly and posteriorly. Both tympanic membranes were bulging in their upper portions. Paracentesis was followed by a free discharge of pus from each ear. There was a purulent postnasal discharge.

The cervical and occipital lymph nodes were hard and shotty.

Laboratory study was essentially negative except for a secondary anemia and leucocytosis. X-ray studies were compatible with the physical findings.

Clinical diagnosis was: 1. Lobar pneumonia right upper and middle lobes. 2. Otitis media bilateral. 3. Chronic paranasal sinusitis. 4. Malnutrition. 5. Probably tuberculosis or syphilis or both.

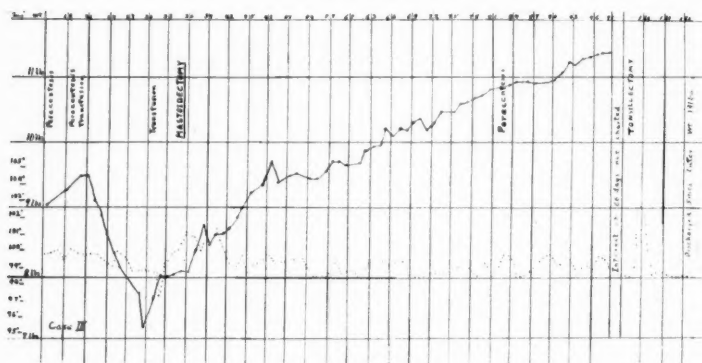
After admission to the hospital the acuteness of the pulmonary lesion subsided rapidly; but the physical findings did not clear up. Six days after admission small purplish spots appeared on her occiput and buttocks. These rapidly enlarged and sloughed out leaving indolent ulcers with bare bone exposed in their bases. Both syphilis and tuberculosis were suspected, but repeated Wassermann, sputum and tuberculin tests were always negative.

The child gradually drifted down hill in spite of intensive medical treatment. Three weeks after admission a moderate diarrhea developed, and her downhill progress was markedly accelerated. The ears had been discharging irregularly, requiring frequent paracentesis. On March 6th, suggestive sagging of the left auditory canal was noted; and X-ray showed some reaction about this mastoid antrum. One week later an attending pediatrician made the following note: "Condition very poor. Skin and bones. It is of grayish color. (A minute description of the physical findings in the chest.) Impression: It seems unlikely that so much involvement could be present in one side of the chest without some recognizable pathology in the other in the presence of tuberculosis. The child's condition does not suggest syphilis to me. The spleen has never been palpable. There has never been a G. G. E., and the liver is down only about one centimeter. I believe that the child has been overwhelmed by the invasion of a nontubercular, nonsyphilitic infection and is slowly dying.

The mastoids or sinuses may be involved in addition to the lung condition." This note clearly shows the seriousness and apparent hopelessness of the baby's general condition.

Mastoidectomy was decided upon, and on March 12th the left mastoid was opened under local anesthesia. Pus was found in the antrum and contiguous bone. Improvement began immediately, and three days after mastoidectomy the following note was made: "General condition much better. Takes all of the formula. Chest condition about the same."

From this time until discharge her general condition improved steadily, but the clinical signs in the chest persisted. X-rays showed considerable reaction throughout the right lung, mostly in the upper lobe, with evidence of slow improvement. Tuberculin and sputum tests were constantly negative for tuberculosis. The child continually ran a low-grade temperature, but gained weight steadily and seemed to feel well. The ulcers had long since healed. She still had a constant purulent nasal discharge. She had several attacks of tonsillitis and otitis media, which subsided promptly and



were not accompanied by serious systemic derangement. On August 8th her tonsils and adenoids were removed under ether anesthesia. This was not accompanied by any increased activity in the chest. The nasal discharge cleared up very shortly after the operation, and the gradual improvement in the pulmonary lesion was definitely speeded up.

Although some irregular temperature persisted, the child seemed to feel fine, and was allowed to be up. This seemed to have no bad effect, and she was soon playing about the ward. On October 27, 1929, she was discharged into an adopted home. With the exception of some coarse and medium rales in the right upper lobe her chest had cleared entirely, but some irregularity of temperature persisted.

On March 5, 1930, she was readmitted with a diagnosis of acute bronchitis, acute otitis media, and pyelitis. These subsided promptly under appropriate treatment. X-ray of chest was reported: "Marked improvement in lungs. Only slight residual infection in the right lung."

She had been well in the interval and weighed twenty-one pounds.

On May 4, 1933, she was readmitted again with a diagnosis of acute bronchitis which soon cleared up. She had been well in the interval and now weighed thirty-five pounds, only slightly below the normal for her age. X-ray of chest was reported: "Considerable reaction along each mediastinal border with enlarged tracheobronchial hilus glands. Also general thickening along the bronchial structures. Considering the appearance of the chest with the studies made in 1929, I believe we have had a chronic infantile tuberculosis with occasional activity." (These pictures were made immediately after an attack of bronchitis.)

Comment.—This child with a profound and rapidly progressing nutritional disorder, grew steadily worse under expert pediatric management. Immediately following mastoidectomy improvement began and progressed steadily. This occurred in spite of infection in the chest and the sinuses. Apparently the mastoidectomy was just enough to throw the balance of play between the forces of resistance and infection over to the side of resistance, and a child who seemed to be hopelessly ill recovered. Regardless of whether the pulmonary infection was or was not tuberculosis, it responded well to eradication of infection in the tonsils and sinuses. When seen last, four years after the first admission, the patient was an essentially normal child. The initial sharp loss of weight was temporarily halted by clyses and transfusion before mastoidectomy was done.

In summary, three cases are reported illustrating the profound effect an infected mastoid may have upon nutritional disturbances in infants. In one of these cases a pylorospasm severe enough to suggest abdominal surgery was relieved following mastoidectomy. In no case was operation resorted to until all means of bringing about cure by medical means alone were exhausted. In all cases the indications for the operation were in the main general rather than local. The three cases have been followed long enough to determine that the results are not temporary.

CONCLUSIONS.

There is ample anatomic, pathologic and clinical evidence to substantiate the belief that infection within the mastoid may have a profound systemic effect in infants.

Mastoiditis associated with a marked nutritional disturbance creates a vicious circle depending upon the interplay of the forces of individual resistance and infection. Break the circle and the child will recover. Increase his resistance by medical therapy and he may conquer the infection; or relieve the mastoiditis by surgery and he will respond to dietary management.

The classical signs of mastoiditis do not present, because the patient has not the resistance to develop sufficient local reaction.

Consequently the indications for operation are mainly pediatric in nature. It is wise not to operate during the initial abrupt loss of weight. Careful pediatric management will usually check this abrupt loss, when operation may be more safely performed.

1111 MEDICAL ARTS BLDG.

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XLVIII.

CARCINOMA OF THE TONSILS: CASE REPORT.*

J. THOMAS DOWLING, M. D.,

MAURICE F. DWYER, M. D.,

SEATTLE.

Carcinoma of the tonsils is not a rare disease and, according to Waters and Kaplan,¹ accounts for 12 per cent of oral carcinomas. These men note the fact that it has been seen in young children. The usual type is an ulcerating growth involving the tonsil and tonsillar pillar. The nonulcerating type may be confused with Hodgkin's disease, or lymphosarcoma; a histologic study therefore is necessary in all cases. Cervical metastases may be simulated by cervical Hodgkin's disease. Most tumors of the tonsil are carcinoma, sarcoma other than lymphosarcoma being rare. Surgical treatment of carcinoma of the tonsil has given poor results, and the lesion is never primarily operable.

Duffy,² in reviewing a series of 122 cases treated between 1921 and 1928 at the Memorial Hospital, New York, notes that ten cases were of grade I carcinoma, eighty-eight of grade II, eight of grade III; eleven were transitional tumors; one was a mixed grade II and transitional cell carcinoma; and in the remaining cases of the series the section was too small to permit grading. There were no cervical metastases in 41.8 per cent of the cases. In 30 per cent cervical metastases were surgically operable, and in 28 per cent the disease was too far advanced for surgical measures.

Nathanson,³ in 1929, reviewed thirty-eight cases of tonsillar cancer observed in the New York City Cancer Institute in the preceding five years and sixty cases observed in the State Hospital for Malignant Disease in the preceding ten years. Most of the cases were in men. Smoking, bad teeth, and syphilis did not

*Read before the Western Section of the American Laryngological, Rhinological and Otolological Society, Portland, Ore., January, 1934.
From the Mason Clinic.

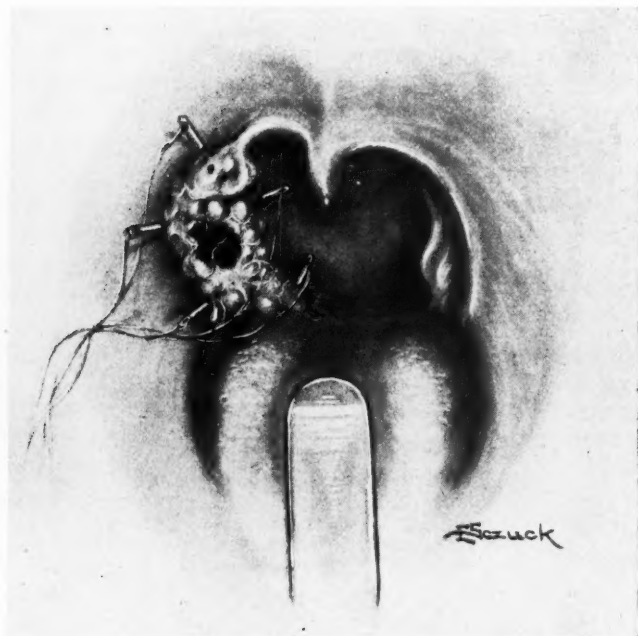


Fig. 1.

appear to be of etiologic importance. The prognosis was bad, as most of the cases were far advanced when first seen and when diagnosis was made.

Canuyt and Micaesco,⁴ in 1929, reviewed 145 cases of carcinoma of the tonsil collected from the literature and twelve observed by themselves. It is pointed out that the tonsil is more frequently the seat of primary carcinoma than all the rest of the oropharynx. Bilateral growths are very rare, only one in the 157 cases reported. These authors think the most important etiologic factor is the abuse of tobacco, especially in syphilitics. They discuss treatment by radical operation, with removal of the upper cervical glands, followed by irradiation by X-ray or radium or both.

Christoforidis⁵ reports twelve cases of carcinoma and fifteen cases of sarcoma treated by him between 1919 and 1927 at the

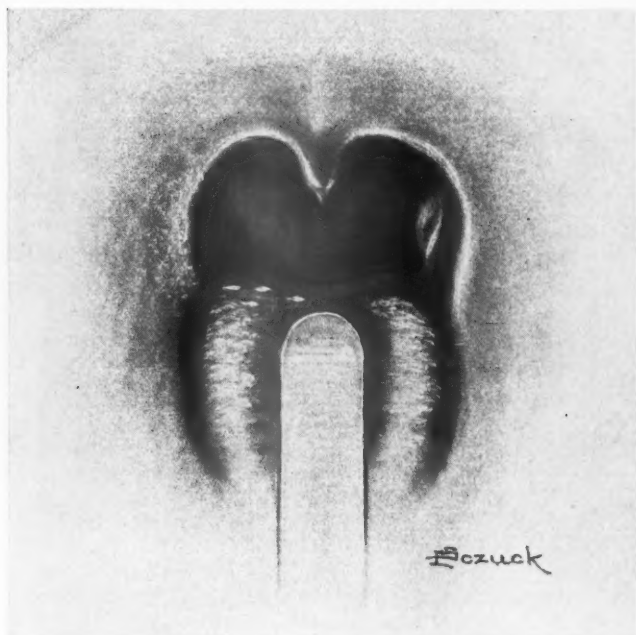


Fig. 2.

University of Leipzig. The cases of carcinoma received treatment by surgery and irradiation combined. The sarcoma cases, treated principally by X-ray, responded very well. The tonsillar growths are very malignant, and the patient rarely seeks relief until the disease is far advanced.

Cade⁶ discusses the radium treatment of cancer and notes that many growths of the tonsil are nonradiosensitive and that the results obtained from this method of treatment are indifferent in these cases. The treatment is divided into two stages. First, resection of the ramus of the lower jaw on the affected side is done, followed by implantation of radium needles about and in the tonsillar growth. Second, immediately following the removal of the radium, a plaque containing 30 mg. of radium is applied to the tumor mass and left for twelve hours daily for five or six days.

McKinney⁷ feels that all malignant disease of the tonsils should first be treated by radium and high voltage X-ray so that a blocking of the lymphatics may take place. The treatment should be carried on by an expert and highly trained roentgenologist in conjunction with the rhinolaryngologist.

Carcinoma of the tonsils is not a surgical condition and is best treated by irradiation. The interstitial implantation of platinum filtered radium needles about the growth, the surface application of heavily filtered radium capsules to the lesion, and X-ray therapy externally is a very satisfactory method and in all probability the best way of dealing with this serious condition. Statistics show that approximately one-fourth of patients with carcinoma of the tonsils survive the five-year period.

Following is a report of our own case:

R. M. (Case No. A-45087), male, 50 years of age, married, a worker in a powder plant, was referred to us September 1, 1932, complaining of sore throat and swelling in the region of the right tonsil. Family and past history were of no particular significance. The Wassermann test of the blood was negative and the blood count was normal.

Examination showed a swelling of the right tonsil, which the patient stated was of about three months' duration. This swelling consisted of a tumor with an ulcerating surface and involved the tonsil and posterior pillar, extending somewhat to the adjacent surface of the tongue. There was a hard indurated zone surrounding the ulcerated area. No cervical glands were palpable. The act of swallowing was somewhat interfered with by the tumor but was not painful. A section of the tumor mass was taken for microscopic examination and was reported to be epithelioma grade III. Under local anesthesia, radium needles were inserted about the growth.

The case here reported received the following treatment: On September 6, 1932, five 0.6 mg. platinum needles with wall thickness of 0.5 mm. were inserted about the growth approximately one centimeter apart. Each needle was sutured in place in order to retain it in position. Five needles remained in position for five and a half days. At the end of this time one needle became dislodged and was removed, the remaining four needles being removed twenty-four hours later, making a total administration of 396 milligram hours. The patient complained of some pain the day following the insertion and suturing of the needles, but the following day and thereafter for the remaining five days there was no pain, only a slight soreness, and he was able to eat his regular meals.

On September 15, two platinum capsules, with walls 0.8 mm. thick, each capsule containing 25 mg. of radium, were applied to the surface of the tonsil and held in place by a lead applicator for four hours, giving a total of 200 milligram hours. The tonsillar fossa received thus a total radium irradiation of 596 milligram hours. Examination of the throat at

this time showed marked reduction in the size of the growth. The hard ridge surrounding the tonsillar fossa had disappeared, and there had been practically no reaction.

On September 30th, X-ray therapy was begun. The right side of the face and neck was irradiated, using 200 K. V., 0.5 mm. copper filtration, 20 cm. distance, administering 720 roentgens. One-half this amount was given on September 30 and the other half October 1. One week later, October 7, 215 roentgens were again administered. The patient was kept under close observation, and from this time on no evidence of the lesion could be seen. There was moderate scarring of the tonsillar fossa, but aside from that the throat appeared normal. At no time were the cervical glands palpable. Beginning on November 11th, a second series of X-ray treatments were given, and 755 roentgens were administered. There was considerable skin reaction following this course of treatments, which, however, subsided in a week.

The patient was last seen January 2, 1934, and was clinically well at that time.

CONCLUSIONS.

1. Carcinoma of the tonsil is not a rare condition and is very malignant in the great majority of cases.
2. About 41 per cent of the cases reported had no demonstrable metastases.
3. The opinion of the writers quoted is about equally divided as to the possible effect of tobacco in syphilitics.
4. A preponderance of the cases were in men.
5. All authorities agree that radium and X-ray therapy give by far the best results in selected cases.
6. The prognosis is bad, especially when all cases are grouped in a statistical study.

THE MASON CLINIC.

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XLIX.

NASAL FOREIGN BODIES: REPORT OF A CASE HAVING LODGMENT FOR SEVEN YEARS.

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HONOLULU.

The nose has been harassed repeatedly by the presence of foreign bodies. Many considerations arise to make their existence an intrusion of interest and import in scientific study. Their variety, number and methods of gaining entrance, rather frequent occurrence in juveniles, gravity of certain cases—more particularly those evading detection over a considerable length of time—with possible complications, the usually spontaneous cure after removal, all must engage our attention.

While usually foreign bodies of the nose are referred to in a lighter vein, in the average case having a brief sojourn, lending with ease to diagnosis and removal, cases arise which tax the ingenuity of the most discerning. It is just that fact that has prompted me to issue this brief digest.

Grossly, foreign bodies of the nose are either animate or inanimate. Probably in the tropical clime we see a few more of the former than elsewhere. Recent unauthenticated reports added scorpions to the list. In India, there have been reports of invasions of the nose with leeches as offenders, by Astavans,¹ Khan² and Narasimhaiah.³

Inanimate foreign bodies in the nose constitute quite a variety. Some are hydroscopic, such as corn, peas, beans, etc. Those of nonhydroscopic nature probably most often are stones, shells, coins, etc. Others form in situ, as rhinoliths, usually around an infected knidus. Sequestra occasionally are found, particularly in certain constitutional diseases. Probably all long-standing cases of nasal foreign bodies are inanimate. Voorhees⁴ reported a case in which a bolt, one-half by two and one-eighth inches, had been present in the nose of a negro for seventeen years. Camerer⁵ likewise reported a case in which a seaman's nose was host to

a cork for seventeen years. While these are isolated and rare cases, it is conceivable that others may have evaded detection and thus endured untold annoyance.

Most foreign bodies gain admittance through the anterior nares. This is especially true among adventurous children. Other methods are through the posterior nares and also directly through the nasal tissues in traumatic cases. Still others, as ivory and bone, may be voluntarily placed by the plastic surgeon. Too, pledgets of cotton oftentimes are introduced in nasal therapy, but rarely (through an oversight) have been allowed to remain.

Detection of nasal foreign bodies is commonly easy, and history of the case of encroachment or insertion is often elicited. Occasionally adults (usually insane) have been observed introducing coins into the nostrils, more often the right, corresponding with the predominance of right-handed individuals. However, this finding is not borne out by all rhinologists. In the early years the child is, as a rule, ambidextrous. Hence statistics may vary, depending upon the age groups considered.

The use of a silver probe should not be lost sight of in foreign body detection. Being malleable and flexible, it becomes a very valuable adjunct, especially when inspection is impossible. When manipulated against a firm obstacle, it often gives a metallic sensation, thereby aiding in both detection and diagnosis.

History of prolonged unilateral nasal discharge in a child should cause us to think first of a foreign body as the etiologic agent. The nature of the discharge, in early cases serous, may become muco-sanguineo-purulent, and in long-standing cases fetid. Unilateral nasal obstruction accompanies the discharge, but later on, the signs and symptoms are not confined to one side. Frequent sneezing attacks are not unusual. A feeling of discomfort in the nose, rather than actual pain, is the usual finding. The voice may have a nasal quality. Rarely do we find rather free epistaxis, but this may occur in the presence of foreign bodies having sharp edges, especially upon external manipulation of the nose, which is almost reflexly resorted to by the afflicted person. The X-ray frequently clinches the diagnosis in showing objects of greater density than the surrounding structures.

Disconcerting symptoms elicited by the patient or haste or anxiety on the part of the specialist should never intervene to prevent a painstaking rhinologic examination. Equal parts of adrenalin, 1:1000, cocain, 4 per cent, and ephedrin, 2 per cent, used two or three times as a nasal spray at five-minute intervals, serve as a very effective astringent and anesthetic to the nasal mucosa. Then the probe plays its greatest rôle.

Removal of nasal foreign bodies, as a rule, requires little dexterity, and surgical intervention rarely is necessary. All should be removed without delay, more especially those in the space between the septum and turbinates. If the object is far forward and present for only a brief period, it is usually removable by a silver probe bent as desired. A pair of toothed forceps or ordinary nasal dressing forceps are often useful. The use of suction is proving very satisfactory when the foreign body is readily approached and is not impacted. Oftentimes it becomes necessary to administer a general anesthetic in children, and likewise to produce local anesthesia in adults before making much progress.

REPORT OF A CASE.

A Japanese male, aged 31, came to the clinic complaining of having right-sided nasal blocking, boils and bleeding intermittently for the past seven years. A large scar, involving the right cheek and nasal vestibule, a portion of the upper lip and an area below the left angle of the mouth, was noted, which the patient stated was inflicted in an automobile crash seven years ago. The accident story was secured only after expenditure of time and energy. The original operation was done by a general surgeon. Later a plastic operation upon the right side of the nose was attempted by a rhinologist—which proved partially successful—and still later on repeated cauterizations to control the epistaxis, administered by several physicians and surgeons. The scar, encroaching upon the right vestibule, decreased its caliber about 35 per cent. Veins in Keisselbach's space were not markedly altered. All right-sided mucosa was markedly hyperplastic on inspection, the passageway being practically all blocked. There was a small amount of muco-sanguineo-purulent discharge coming from the right side, the left being of normal aspect throughout.

The nose was sprayed several times with the combination of cocain, ephedrin and adrenalin. Curving the silver probe distally to form an acute angle and drawing it forward with the point sliding along the floor of the nose, it finally entered a small sinus about 1 cm. from the entrance. The sinus opened superiorly and posteriorly and therefore could not be detected by inspection. At the floor of the sinus the probe contacted a movable, grating object. Thorough exploration resulted in detection and removal of a piece of glass (evidently windshield), .5 by 1.1 cm. and about

1 mm. in thickness, which is added to the souvenir column. The cavity was cleaned, then swabbed with 5 per cent silver nitrate solution. In about two weeks the area has healed completely and the general condition of the patient has improved to an almost incredible degree.

65 ALEXANDER YOUNG BUILDING.

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L.

REPORTS OF THREE CASES OF RUPTURE OF
ABSCESSSES INTO THE EXTERNAL AUDITORY
CANAL OTHER THAN THAT OF THE
PAROTID.*

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BOISE, IDAHO.

The rupture of an abscess into the external auditory canal is extremely rare and is occasionally accompanied by the most dangerous sequelæ. A careful perusal of the literature and the records of the accumulative quarterly index for the past twenty years reveal the marked scarcity of these cases. Campbell¹ and Bertoin² both mention their rarity.

Any infection that endangers the lymphatic system of the neck should put us on guard. Mosher,³ in his "Pterygo-Maxillary Fossæ," points out many of the dangers connected with this area, and my experience in this area has been most harrowing, to-wit: Two cases of complete degeneration of the internal jugular, one degeneration of the common carotid and one of the inferior thyroid vein.

Case No. 1.—A male, age three and one-half, chief complaint pain in right ear and side of neck, began following a sore throat. Ear examination negative; no swelling or inflammation of drum, considerable swelling beneath the ear and in neck glands. Two days later a large amount of blood and pus was discharged from the right external auditory canal. Examination of the ear drum showed it to be negative, but there was seen a punched out hole in the lower portion of the external auditory canal. Under gas anesthesia, a malleable probe was inserted into the opening in the external canal and it descended about an inch and one-half. Pressure on the neck caused pus and blood to escape through the opening into the external auditory canal. The temperature was 102, the pulse 140, white blood count 10,000. X-ray of the mastoid negative. The tonsils were definitely enlarged and there was some retropharyngeal swelling.

Five days later his temperature had returned to normal, the swelling had receded from his pharynx. The tonsils were removed under general anesthetic, and the boy made a rapid, uneventful recovery.

*Presented before the Western Section of the American Laryngological, Rhinological and Otological Society, Portland, Oregon, January 12, 1934.

Case No. 2.—Female, age five. Previous history negative. One month before complained of pain in right ear which lasted only a short time. On April 2, 1931, complained of feeling chilly and did not care to play. Stated that there was some pain in the right ear. On April 3rd the family doctor was called. Child stated that her ear hurt, "that it didn't ache, but was sick." That afternoon she was taken to the doctor's office and he noticed that there was some swelling and tenderness below and in front of the ear.

The child was sent home and put to bed. The following day she complained that her neck was stiff and she held her head decidedly over to the right side. She also complained of some difficulty in swallowing. She was kept in bed. Her neck continued to be stiff, but she was not seen again by her doctor until April 12th.

Her mother stated that while the child was playing in bed on April 12th there was a sudden severe hemorrhage from the right nostril and the right ear. This occurred shortly after eleven o'clock in the morning. She was taken immediately to the hospital where it was noted that the child seemed to be very weak and pale. The temperature was 101, the pulse 130. Proctocytosis was started. At two o'clock there was another severe hemorrhage from the nose, the blood coming in spurts. Later the same day the chart recorded that fresh blood was flowing freely from the right ear. The pulse had gone up to 150. At seven o'clock that night a transfusion of 75 cc. of citrated blood was given. The following day the chart records profuse bleeding from nose and ear, pulse 170, temperature 103.4. Proctocytosis continued.

On April 14th, I was called in to see the child after it had been taken to the surgery. Remembering the experience with Case 1, I carefully cleaned the external auditory canal; the drum was found to be normal. However, there was an elevated area in the floor of the external auditory canal that drained pus and blood when pressure was made on the neck. A malleable probe was inserted into this sinus. It extended down into the neck for a little over two inches. This opening was nearer the drum than in Case 1. It struck me at the time that certainly the deep vessels were greatly endangered. The throat and pharynx were examined and pressure on the external neck caused pus and blood to well into the pharynx from a retropharyngeal abscess. The child's condition was so serious that she was returned to her room. The bleeding continued from the nose and throat at intervals during the day. On the 15th there was very little bleeding. On the 16th there was an increase in the bleeding from the nose and ear, but the general condition seemed to be somewhat improved; the pulse had dropped to 140. At two p. m. the child was again taken to the surgery, and under ether anesthetic a fairly long incision was made beneath the angle of the jaw and the neck was freely opened. Profuse and almost uncontrollable bleeding occurred. It was impossible to pick up a definite bleeding point. A strip of iodoform gauze was tightly packed into the neck cavity and the bleeding stopped. A second transfusion was given. The following day there was some bleeding from the nose and ear and the child complained bitterly of pain in the frontal and the parietal region. April 18th, the child was very drowsy. Temperature 100, pulse 122. Most of the iodoform pack was removed. There was no bleeding. April 19th, very little bleeding, the child was exceedingly restless. There

was no further bleeding on April 20, 21 and 22, pulse was slower and of better quality, but the child was restless most of the time. On April 23rd the child developed a complete hemiplegia of the left side. There was no further bleeding from the nose or ear. However, the hemiplegia remained quite complete for six days. On the 29th a slight movement of the left foot was noticed. The child was taken home on May 1st. In seven months the hemiplegia cleared up entirely with the exception of slight spasticity of the left fingers and a not very noticeable drag of the left foot.

Case 3.—Female, age 27. Three weeks previously had had a furuncle beginning in the left ear. This was partially opened several times by her family doctor. Eight days previous to being referred to me she began to develop a swelling in the cervical glands below the ear. The swelling at the time I saw her extended over the entire left side of her face, and there was a marked area of tenderness beneath the angle of the jaw. The external canal was badly swollen. The patient was unable to open her mouth more than a quarter of an inch. There was marked difficulty in swallowing and her voice was slightly husky. There was very little pus in the canal. Temperature 102, white blood count 17,000. Frequent doses of morphin previous to the time I saw her did not relieve the pain.

The next day under a general anesthetic an opening was made beneath the angle of the jaw. All the glands were very large, the superficial ones were not broken down, but there was a small amount of serum present in the glands. The patient took the anesthetic very badly, examination of pharynx showed some swelling, but not enough to warrant surgery. The patient was returned to her room. Continuous heat was used on the side of her neck. Two days later a large amount of pus was discharged through the external auditory canal and it was noticed that the patient had a slight facial paralysis. Irrigation through the first incision in the neck returned pus and blood through the external auditory canal. The swelling in the larynx soon subsided and after three weeks the patient made an uneventful recovery. The facial paralysis cleared up entirely.

The case reported by Edward H. Campbell¹ was similar to the last case that I have reported. Campbell also refers to cases reported by Eves,⁴ Fulkerson, C. B.,⁵ and Dan McKenzie.⁶

M. Roger Bertoin,² in the French journal, *Lyon Medical*, reports a case entitled "Spontaneous Opening of Peritonsillar Abscess into the External Auditory Canal." I think it is of interest to report in detail his observations. His report is as follows:

"Josephine, 10 years old, was presented to us on April 12, 1931. Several days before, her doctor had determined undoubtedly the existence of a peritonsillar abscess on the right side, accompanied by fixation of the jaw. He hesitated at first, and then decided to interfere. With the forefinger of the left hand he explored

the anterior pillar. Almost immediately a veritable flood of pus gushed out through the external auditory canal. The same maneuver hurried along the production of the same phenomenon. However, the tenseness of the area was greatly diminished. Immediately the mouth opened easily, fixation ceased spontaneously. The right anterior pillar is slightly swollen; the tonsil is of normal size.

"The auditory canal is filled with pus; after cleansing the canal, the drum of the ear is perceived to be a little red without a trace of perforation. As a setoff on the lower wall, towards its middle part, is found a little fleshy boil, with edges slightly upturned, which hides a hole from which the pus issues.

"Neither upon inspection nor by palpation is anything abnormal in the neck determined. The parotid gland is not enlarged and cervical glands which existed in the beginning have completely disappeared.

Within fifteen days the canal is completely dry and the anterior pillar and tonsil have assumed their usual aspect."

He further goes on to state that "in spite of the rarity of this case, the symptoms of the disease should be known:

"There was formed first a typical peritonsillar abscess. If discovered earlier it might have been easily opened into the pharynx. We have found only one similar observation accounted for, and this by E. Roch⁷ of Geneva:

"Three weeks after a sore throat a little girl of 7 years of age displayed a retrotonsillar abscess. When one pressed on the tonsil one determined the issue of some purulent liquid through a hole situated on the lower wall of the external auditory canal. An incision of the posterior pillar was made. A bent probe was introduced which followed up laterally and posteriorly. The case rapidly recovered."

To Bertoin the greatest interest in these cases consisted in determining the abnormal direction or course followed by the pus. One of his observations is that "the pus first collected in the peritonsillar space and that it may have expanded in the prestyloid space by a weak point situated on the posterior superior part of the pharyngeal wall where the muscular aponeurosis becomes almost cellular.

"On the other hand, it is not rare to see an intraparotid abscess, or one from the parotid fossæ, open itself into the external auditory canal, and we have observed a certain number of these cases. In reality, the anterior side of the fibrocartilaginous groove of the canal is found in very close relation with the superior pole of the parotid gland; their communication, as Gorfass of Athens noticed, can be explained in two ways: (1) Either some inflammatory adhesions formed between the parotid and the canal, making a real chondroperichondritic enclosure bordering upon the perforation; or (2) one can admit the rôle played by the fissures of Santorini, established by a thin fibrous coat covered in front by some cellular tissue and behind by the thin skin of the canal, and incapable of offering great resistance to a collection of pus under tension.

"The delicate point to explain is that of understanding how the collection passes from the prestyloid space into the parotid fossa. Let us recall, only from an anatomic point of view, that the internal wall of this fossa presents a triangular hole placed high up by the base of the skull (from the styloid apophysis to the sphenoid spine), forward by the sphenomaxillary ligament, and containing pharyngeal prolongation of the gland; thus the parotid fossa and prestyloid space prove to be in relation. Nevertheless, the passage of pus in this way is quite exceptional, for it is necessary to follow an oblique direction above and outward, disobeying thus the laws of gravity. We have, upon this subject, demanded the opinion of our colleague, A. Viela of Toulouse, whose works on anatomy and findings on the tonsil are authoritative. He has written to us that, in the course of certain dissections, the pharyngeal prolongation of the parotid is related to the outer aspect of the prestyloid space, and is much in size, being replaced by a vascular cellular tissue, an excellent pathway for the passage of an abscess. Thus, with the case of our sick girl, we hesitated a little before deciding upon interference; the pus had time to collect under high pressure in the prestyloid space and, not being able to create an outlet within, it broke outward through a weak point that happened to reach the parotid fossa.

"Two abnormal conditions seem to have been necessary: (1) The delay of the pharyngeal opening of an abscess collected under

tension in the tonsillar fossa, and (2) the existence of a weak spot in the external part of the prestyloid space."

Eves⁴ in his article mentions that there were three routes that the pus could have followed to reach the external auditory canal: (1) Through the fissures of Santorini; (2) through the fibrous tissues between the junction of the cartilage and bone, which is at times present, especially in children; (3) through a dehiscence of the bony canal, which is present in a small percentage of cases.

Hauge⁸ reported a piece of carded wool that had been inserted into the external auditory canal by a patient himself and later on had been removed from an abscess in the pharynx.

SUMMARY.

1. The occurrence of these three cases of this rare condition within a period of two years is interesting and will certainly keep me on the lookout for another.

2. More careful anatomic studies of the possible pathways for the pus is necessary.

3. I feel as though I might have missed the diagnosis in the first case if I had not read Dr. Edward Campbell's report.

518 EASTMAN BLDG.

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Abstracts of Current Articles.

NOSE.

Effects of Drugs on Ciliary Activity of Mucosa of Upper Respiratory Tract.

Lierle, D. M.; Moore, P. M. (Iowa City), *Arch. Otolaryng.*, 19:55 (Jan.), 1934.

Observations were made on excised human tissue, dog tissue, freshly killed intact guinea pig tissue and on living guinea pig tissue.

1. These workers conclude that tap and distilled water applied to the mucosa of the upper respiratory membrane cause slowing of the ciliary action.

2. Three per cent ephedrin hydrochloride may slightly increase it.

3. Five per cent cocain salt has no effect, but 10 to 20 per cent solutions cause temporary slowing.

4. Silver protein solutions give an initial speeding up with later slowing.

5. Five-tenths per cent eucalyptol has no action.

6. Menthol, thymol and above 5/10 per cent eucalyptol depress.

7. Adrenalin, zinc sulphate, mercurochrome and silver nitrate are definitely detrimental to ciliary action.

TOBEY.

Radical Operation on the Antrum With Evaluation of the Vertical Incision.

Shapiro, S. L.; Fabricant, Noah D.; Stephen, Robt. M. (Chicago), *Arch. of Otolaryng.*, 19:303 (March), 1934.

On seventeen patients requiring bilateral Caldwell-Luc operations, the usual horizontal incision was made on one side and the vertical incision on the other.

After one year these patients were checked up.

No advantage was found in favor of the vertical incision from the standpoint of avoiding postoperative disturbances in sensation. Disturbances of sensation in the teeth were not accompanied by actual changes in the pulp.

TOBEY.

Dentigerous Cysts of the Antrum: Report of Two Cases.

Love, Andrew A. (Los Angeles), Arch. of Otolaryng., 19:348 (March), 1934.

These cysts are characterized by:

1. Having a bony shell easily separate from the antral walls and soft tissues.
2. They have a soft tissue layer composed of fibrous connective tissue sometimes containing thin layers of cartilage or bone, and lined with epithelium, usually stratified squamous.
3. They contain a tooth or teeth more or less completely developed.
4. They contain fluid which is thin and straw colored, containing cholesterol crystal when noninfected but purulent or caseous when infected.

Etiology may be from epithelial rests or retention of fluid in the tooth follicle.

Treatment is removal through the canine fossa region with subsequent drainage through a naso-antral window, and closing the canine fossa opening tightly. Infected cysts may have their shells very adherent to the antral walls.

Prognosis is good when entirely removed.

TOBEY.

Treatment of Atrophic Rhinitis (Ozena) With Polyvalent Stomosine (Preliminary Report) (Italian Test) (Le Stomosine Polivalenti Nella Cura Della Rinite Atrofica Ozenatosa).

Turtur, G. (Rome), Boll. delle Malatt. Orecch. Gola, Naso, 60:373 (September), 1933.

The author quotes briefly numerous researches and the modern therapy employed for the treatment of atrophic rhinitis based on prevailing etiologic and pathologic theories. He refers to his histologic researches, reported in 1916, on the favorable results obtained by the use of ether-iodoform packs as advocated by Bilancioni. He gives his personal opinion of the results from stock and autogenous vaccine and concludes by giving a preliminary report of eighteen cases treated by the use of six to twelve injections of polyvalent stomosine, eliminating the coccobacillus of Perez. This form of treatment has procured very encouraging results, as it eliminates the scabs and fetor, and improves the sense of smell in many cases.

SCIARRETTA.

Histopathologic Notes of the Nasal Mucosa Removed From a Patient Wearing a Tracheal Canula for a Long Time (Note di Istopatologia Della Mucosa Nasale in Portatori di Cannula Tracheale da Lungo Tempo).

D'Onfrio, F. (Naples), Boll. delle Malatt. Orecch. Gola, Naso, 60:388 (September), 1933.

The author has examined histologically pieces of nasal mucosa removed from patients wearing a tracheal cannula for a long period of time. He selected patients that had no evidence of pathology in the nasal cavity prior to tracheotomy but had developed hypertrophic changes which he removed for therapeutic and histologic purposes. The examination revealed destruction of the epithelium down to the basement membrane, hyperplasia of the glands and mild infiltration of the connective tissue.

He thought that these alterations were caused by the stagnation of the mucous discharge and poor nasal ventilation.

SCIARRETTA.

Pseudoneoplastic Forms of Syphilis of the Nasal Fossae (Les formes pseudo-néoplasiques de la syphilis des fosses nasales).

Berger, M. (Bordeaux), Rev. de Lar. Ot. Rhin. 54:973 (September-October), 1933.

Pseudotumors of intranasal structures caused by syphilis may so closely resemble epitheliomas or sarcomas as to require microscopic examination, serologic and bacteriologic results being often inconclusive. Histologically the lesion may be confused with tuberculosis, or may even simulate malignancy. In the latter case appropriate treatment for malignant disease must be used, but only after trial of antiluetic medication. In all doubtful lesions of the mucosal and submucosal structures of the nose, syphilis should be remembered and ruled out.

FENTON.

Plasmacytoma of the Nose and Nasopharynx.

Pollock, Frederic J. (Boston), Arch. of Otolaryng., 19:311 (March), 1934.

Two cases of plasmacytoma of the nose and nasopharynx are reported, one a proved case of multiple myeloma and the other showing no skeletal involvement. These plasma cell tumors are probably true neoplastic origin, although many of the cases reported seem benign.

TOBEY.

Management of Chronic Sinus Disease.

Smith, Ferris (Grand Rapids), Arch. of Otolaryng., 19:157 (February), 1934.

The author discussed only the chronic cases in which nasal surgery for drainage and ventilation, followed by intelligent conservative nasal treatment, have failed and in which the pathologic process is so advanced that only "complete" surgery can effect a cure.

The author has made additions to the accepted radical surgical procedure and has developed instruments to expedite its execution.

The operation is done without pain under local anesthesia with a practically bloodless field and all of the fronto-ethmo-sphenoid sinuses are widely opened and all lining membrane removed. The technic is described in detail and illustrations given. Five hundred patients have been operated on by this method and the results are excellent and stated.

TOBEY.

PHARYNX.**Malignant Tumors of the Nasopharynx (Les tumeurs malignes du nasopharynx).**

Ducuing, J. and L. (Toulouse), Rev. de Lar. Ot. Rhin. 54:1213 (December), 1933.

This is a well-documented and complete paper from the Cancer Clinic of Toulouse, with excellent diagrams showing methods of propagation of these growths, symptom complexes resulting, and especially the cranial nerves and lymphatics concerned.

Such growths are rare—15 out of 17,000 cases in Toulouse; 32 of 70,000 examined in Bordeaux.

Symptoms are grouped as follows: Aural, due to tubal obstruction; respiratory, interfering with nasal breathing; neurologic, causing sphenopalatine or trigeminal neuralgias, and also by invasion causing five syndromes based on interference with the course of cranial nerves; glandular, occurring in at least half the cases and always suggesting hidden malignancy; and hemorrhagic, which are very rare. The nerve syndromes include that of the optic nerve, those of the sphenoid fissure, and maxillary fifth nerves; the Gradenigo syndrome; the posterior foramen lacerum (ninth, tenth and eleventh); the same, adding the twelfth; the same, adding the cervical sympathetic; and in late stages, loss of all cranial nerves of the affected side.

The authors recommend digital examination of the nasopharynx followed by biopsy. Prognosis is bad, no matter what treatment is given; nevertheless much comfort may be secured and the end much delayed by electrocoagulation, radium or deep roentgen therapy. Surgery is recommended only for pedicled growths. Radiation results are best with the lymphosarcomas, poorest with certain epitheliomas. Recurrence, metastasis and death from six weeks to eighteen months after treatment has begun are the usual results.

FENTON.

LARYNX.

Benign Goiters and Recurrent Paralysis.

Feuz, J. (Lausanne), *Rev. de Lar. Ot. Rhin.* 55:32 (January), 1934.

Based on a study of all goiter operations since 1929 in the Cantonal Hospital, Feuz considers postoperative recurrent paralysis an accident of grave import from a social and psychic standpoint.

Voice changes are not indicative of the condition of the nerve, nor do voice changes during an operation mean that the nerve is damaged; conversely, a clear voice all through the operation does not mean that the nerve is all right. Postoperative factors: edema, hemorrhage, swelling, may give transitory recurrent symptoms. Because of accommodative changes by the other cord, recurrent paralysis may exist without the "cracked" voice.

Feuz states that careful study of the cords should be made preoperatively, immediately after operation, and again in two weeks. If paralysis occurs, it should be watched for a year or more. Recurrent paralysis noticed prior to operation and due to stretching or compression of the nerve by benign goiters are rare, but their prognosis is bad.

FENTON.

The Control of Hemorrhage in Laryngofissure.

Öhngren, G. (Stockholm), *Acta Oto-Lar.* 19:452 (4), 1934.

To avoid packing and recurrent bleeding Öhngren ties the superior laryngeal artery on the side of the neoplasm, just after his skin incision, raising the thyrohyoid muscle and separating the artery from the superior laryngeal nerve. This shortens delay from operative bleeding and permits immediate safe closure of the fissure.

FENTON.

EAR.**Cerebral (Ventricular) Hydrodynamic Test for Thrombosis of the Lateral Sinus.**

Dandy, Walter E. (Baltimore), *Arch. of Otolaryng.*, 19:297 (March), 1934.

Dr. Dandy found the ventricular dynamic test to be equally as accurate as the Tobey-Ayer test for thrombosis of the lateral sinus.

The procedure is suggested only when a ventricular puncture has been found necessary in diagnosing a suspected brain abscess or brain tumor case, by ventriculography. TOBEY.

The Mastoid Cells—Their Arrangement in Relation to the Sigmoid Portion of the Transverse Sinus.

Meltzer, Philip E. (Boston), *Arch. of Otolaryng.*, 19:326 (March), 1934.

The lateral sinus does not influence the type of pneumatization, as this is dependent on the character of the epithelium and sub-epithelial tissues early in life, but the lateral sinus does limit pneumatization and causes a definite arrangement of the cells in relation to it.

The author states that the cellular pattern is known, once the sinus plate is exposed, and only negligence will result in an incomplete operation. The lateral sinus offers an internal landmark to the surgeon comparable in importance to the external landmark guiding one to the antrum. TOBEY.

Pneumatization of the Temporal Bone.

Tremble, G. Edward (Montreal), *Arch. of Otolaryng.*, 19:172 (February), 1934.

The literature is reviewed on the subject and views of Politzer, Ruttin, Wittmack, Schwarz, Mauret, Cheatle, Neumann and other authorities are discussed from an anatomic, developmental, pathologic and clinical standpoint.

A corrosion cast of the temporal bone of a 4-year-old child and fusible metal casts of a pneumatic, a diploic and a sclerotic bone were made and illustrations shown.

How pneumatization of a temporal bone may affect clinical mastoiditis and its various and grave complications are discussed.

TOBEY.

Recent Advances in the Physiology of Hearing.

McNally, W. J. (Montreal), *Arch. of Otolaryng.* 19:201 (February), 1934.

The higher forms of fish can hear and differentiate between some tones and noises, and their hearing apparatus is discussed.

In man, the cochlea is the organ of hearing and the basilar membrane is the most likely resonating mechanism for resolving sounds into their simple constituent component parts.

A modified resonance theory of hearing is most likely correct.

A fusion of impulses takes place in the acoustic analyzer, the nucleus of which is in the temporal lobe, but remnants of the analyses are distributed throughout the whole mass of the cortex.

The absolute bone conduction test should be used in testing hearing.

Lesions of the middle ear in infancy cause a loss of hearing by air conduction for higher tones rather than lower tones. Tests of hearing are of little value in detecting early otosclerosis.

In drawing these conclusions, the literature has been reviewed and investigations of many important workers are discussed.

TOBEY.

Anatomic and Histologic Studies of the Reticulo-Histiocytic System of the Internal Ear (Contributo Allo Atudio Anatomico ed Istologico del Sistema Reticolo-Istiocitario Dell'Orecchio Interno).

Liveriero, E. (Torino), *Il Valsalva*. 9:585 (August), 1933.

The author gives numerous reasons why the term reticulo-endothelial is incorrect and adopts the term reticulo-histiocytic as termed by Maximow.

He then reviews various researches of the reticulo-endothelial system in the field of otorhinolaryngology.

Bruzzi studied it in the tonsils; Jannuzzi and Bozzi in the pharynx, larynx and trachea; Bianchi in the internal ear; Russi in the auditory apparatus; D'Antona in the nose; and recently Fenton and Larsell in the paranasal sinus mucosa, the middle ear and the eustachian tube.

Finally he gives the results of his investigations on the behavior of the reticulo-histiocytic system of the internal ear of healthy guinea pigs and of guinea pigs inoculated with cultures of streptococcus hemolyticus in the tympanic cavity, using trypan blue for

vital stain. Negative results were found in healthy animals. There were a few granules in the healthy ear of the infected animals, but in the inoculated ear numerous granules were located, mostly in the spiral ligament, some in the periosteal covering of the scala tympani and rarely a few around the capillaries which accompany the acoustic nerve.

The article is accompanied by three microphotographs, a colored illustration and the technic for the preparation of the temporal bone.

SCIARRETTA.

MISCELLANEOUS.

New Surface Anesthetics in Oto-rhino-laryngology (Os novos anestésicos de embebição em O.-R.-L.)

Albernaz, P. M. (Campinas), Rev. O. R. L. de S. Paulo 1:8345 (September-October), 1933.

The author considers butyn more analgesic and much cheaper than cocain, though slightly more toxic. Percain, also cheaper, is the most intense in its local effects, and thus much cheaper because weak solutions are used; this also minimizes its high toxicity. He is similarly pleased with results from pantocain, and has given up cocain altogether.

FENTON.

NOTICE.

CERTIFICATION OF SPECIALISTS IN MEDICINE.

The present trend toward specialization in medicine with the lack of fixed minimum requirements for training and experience in special work has called attention repeatedly of late to the urgent need for official recognition and certification in the United States of fully qualified specialists in various branches of medicine.

Examining Boards have been established and functioning for several years in ophthalmology, otolaryngology, obstetrics and gynecology, dermatology, and more recently in pediatrics. Boards are now being formed in radiology and orthopedic surgery as well as in several other special branches of medicine. Citizens of the United States and Canada are equally eligible for examination.

Each of these Boards is composed of members appointed by the nationally recognized special societies, and the related Sections of the American Medical Association.

Their requirements and examinations for certification are rigid and searching, and a recent editorial in the *Journal of the American Medical Association* makes the following statement:

"As information concerning the work of these Boards becomes more widely disseminated among both the medical profession and the public, their prestige must grow. Eventually the young man who wishes to make for himself a place in any of these specialties will consider the securing of a certificate by a council-recognized certifying board as the first step in such a procedure. Hospitals will also do well to be guided in their staff appointments by similar qualifications. Movements of this type necessarily develop and advance slowly. However, . . . there is reason to believe that the certifying boards will do much to advance the quality of specialistic service available to the people and to the profession of our country."

Announcement is made of the formation of the Advisory Board for Medical Specialties, previously referred to editorially by the *Journal of the American Medical Association*. The purpose of this

Advisory Board is to co-ordinate the activities of the various official groups already concerned with postgraduate medical education in the specialties, and to standardize their methods of work and the certification of medical specialists by the existing Boards.

It is composed of representatives from the following groups: The Association of American Medical Colleges, The American Hospital Association, The Federation of State Medical Boards of the United States, The National Board of Medical Examiners, The American Board of Ophthalmology, The American Board of Otolaryngology, The American Board of Obstetrics and Gynecology, The American Board of Dermatology and Syphilology, and The American Board of Pediatrics. Examining boards in other specialties may be eligible for representation on this Board upon meeting certain high standards of qualification.

The officers are: President, Dr. Louis B. Wilson of Rochester, Minn.; Vice-President, Dr. J. S. Rodman of Philadelphia; Secretary and Treasurer, Dr. Paul Titus of Pittsburgh, and members of the Executive Committee, Dr. W. P. Wherry of Omaha and Dr. W. B. Lancaster of Boston.

It is obvious that this Advisory Board for Medical Specialties should have an important influence in an advisory way on undergraduate medical education as well as graduate education in the specialties; it will assist in the active investigation and listing of postgraduate training facilities, both in the United States and Canada, and to a lesser extent abroad, so much of which has already been done in this country by the Council on Medical Education and Hospitals of the American Medical Association; and it should be an important influence in effecting a general improvement in the standards of practice in the various specialties. It has been seriously suggested that the time may soon come when the various States will license physicians to practice as specialists and that American Boards' certificates will be the basis for such a license. One province in Canada already licenses all of its specialists.

It is expected and planned that this Advisory Board for Medical Specialties will be reportable to and work under the general direction of the Council on Medical Education and Hospitals of the American Medical Association, the latter to be affiliated in a

judicial capacity. The details of this affiliation have not yet been completed. Merritte W. Ireland, Surgeon-General of the United States, and Dr. W. D. Cutter of Chicago represented the Council as observers at the recent meeting of the Advisory Board in Chicago.

The next edition of the American Medical Directory plans to publish information about the acceptable special Boards as well as to indicate those physicians who are Diplomates of the Boards. Plans are likewise being formulated for the proposed publication of a Directory of Diplomates which shall also contain information regarding postgraduate training facilities, special residencies available, and general qualifications necessary for certification and such official recognition as a specialist in any given branch of medicine.

The next meeting of the Advisory Board will be held in Cleveland, Sunday, June 10, 1934, or immediately prior to the next annual session of the American Medical Association.

NOTICE.

The series of articles by Dr. Guggenheim dealing with the cause of otosclerosis has been discontinued and will appear, when completed, in book form. The numerous illustrations and other factors made it impracticable for the *ANNALS* to continue its publication.

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